

**COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN II)
NORTHERN AND CENTRAL CALIFORNIA, NEVADA, AND UTAH**

**Contract Number N62474-94-D-7609
Contract Task Order 267**

Prepared for

**DEPARTMENT OF THE NAVY
Mr. Gil Rivera, Remedial Project Manager
Engineering Field Activity West
Daly City, California**

**DRAFT FINAL
SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan/Quality Assurance Project Plan)**

**TIME-CRITICAL REMOVAL ACTION AND SUPPLEMENTAL SAMPLING ACTIVITIES
SITE 31 (AREA OF CONCERN 1)
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD
CONCORD, CALIFORNIA**

August 23, 2002

DS.0267.17684

Prepared by

**TETRA TECH EM INC.
135 Main St, Suite 1800
San Francisco, CA 94101**



Rik Lantz, R.G., Tetra Tech EM Project Manager

**DRAFT FINAL
SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan/Quality Assurance Project Plan)**

**TIME-CRITICAL REMOVAL ACTION AND SUPPLEMENTAL SAMPLING ACTIVITIES
SITE 31 (AREA OF CONCERN 1)
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD
CONCORD, CALIFORNIA**

Contract Task Order No. 267

Prepared for:

U.S. DEPARTMENT OF THE NAVY

REVIEW AND APPROVAL

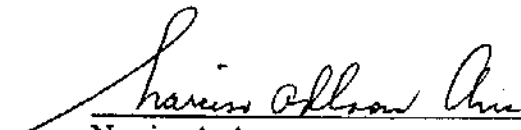
TtEMI Program QA Manager:


Greg Swanson

Date:

8/19/02

Navy QA Officer:


Narciso A. Ancog

Date:

8/20/02

DISTRIBUTION LIST

<u>Name</u>	<u>Responsibility</u>	<u>Affiliation</u>
Mr. Gil Rivera	Remedial Project Manager	Naval Facilities Engineering Command Engineering Field Activity West (EFA WEST)
Narciso A. Ancog	Quality Assurance (QA) Officer	Naval Facilities Engineering Command Southwest Division (SWDIV)
Mr. James Pinasco	Project Manager	California Environmental Protection Agency Department of Toxic Substances Control
Mr. Phillip Ramsey	Project Manager	U.S. Environmental Protection Agency (EPA)
Mr. Laurent Mellier	Project Manager	California Regional Water Quality Control Board-Central Valley Region
Greg Swanson	Program QA Manager	Tetra Tech EM Inc.
Ron Ohta	Project QA Officer	Tetra Tech EM Inc.
Rik Lantz	Project Manager	Tetra Tech EM Inc
Sarah Woolley	Analytical Coordinator	Tetra Tech EM Inc.
TBD	Field Team Leader	Tetra Tech EM Inc.

TABLE 1
ELEMENTS OF EPA QA/R-5 IN RELATION TO THIS SAP

EPA QA/R-5 QAPP ELEMENT	TtEMI SAP
A1 Title and Approval Sheet	Title and Approval Sheet
A2 Table of Contents	Table of Contents
A3 Distribution List	Distribution List
A4 Project/Task Organization	1.4 Project Organization
A5 Problem Definition/Background	1.1 Problem Definition and Background
A6 Project/Task Description	1.2 Project Description
A7 Quality Objectives and Criteria	1.3 Quality Objectives and Criteria
A8 Special Training/Certification	1.5 Special Training and Certification
A9 Documents and Records	1.6 Documents and Records
B1 Sampling Process Design	2.1 Sampling Process Design
B2 Sampling Methods	2.2 Sampling Methods
B3 Sample Handling and Custody	2.3 Sample Handling and Custody
B4 Analytical Methods	2.4 Analytical Methods
B5 Quality Control	2.5 Quality Control
B6 Instrument/Equipment Testing, Inspection, and Maintenance	2.6 Equipment Testing, Inspection, and Maintenance
B7 Instrument/Equipment Calibration and Frequency	2.7 Instrument Calibration and Frequency
B8 Inspection/Acceptance of Supplies and Consumables	2.8 Inspection and Acceptance of Supplies and Consumables
B9 Non-direct Measurements	2.9 Nondirect Measurements
B10 Data Management	2.10 Data Management
C1 Assessment and Response Actions	3.1 Assessment and Response Actions
C2 Reports to Management	3.2 Reports to Management
D1 Data Review, Verification, and Validation	4.1 Data Review, Verification, and Validation
D2 Validation and Verification Methods	
D3 Reconciliation with User Requirements	
	4.2 Reconciliation with User Requirements

Notes:

EPA	U.S. Environmental Protection Agency
QA/R5	"EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5" (EPA 2001)
QAPP	Quality assurance project plan
TtEMI	Tetra Tech EM Inc.
SAP	Sampling and analysis plan

CONTENTS

<u>Section</u>	<u>Page</u>
REVIEW AND APPROVAL.....	i
DISTRIBUTION LIST.....	ii
ACRONYMS AND ABBREVIATIONS.....	ix
 1.0 PROJECT DESCRIPTION AND MANAGEMENT.....	 1
1.1 PROBLEM DEFINITION AND BACKGROUND.....	1
1.1.1 Purpose of the Investigation.....	2
1.1.2 Problem to be Solved.....	2
1.1.2.1 TCRA Sampling Activities.....	2
1.1.2.2 Supplemental Sampling Activities.....	4
1.1.2.3 Optional Sampling Activities.....	4
1.1.3 Facility Background.....	5
1.1.4 Site Description.....	5
1.1.5 Physical Setting.....	5
1.1.6 Summary of Previous Investigations.....	5
1.1.7 Principal Decision Makers.....	7
1.1.8 Technical or Regulatory Standards.....	7
1.2 PROJECT DESCRIPTION.....	8
1.2.1 Project Objectives.....	8
1.2.1.1 TCRA Sampling Activities.....	8
1.2.1.2 Supplemental Sampling Activities.....	8
1.2.1.3 Optional Sampling Activities.....	9
1.2.2 Project Measurements.....	9
1.2.2.1 TCRA Sampling Activities.....	10
1.2.2.2 Supplemental Sampling Activities.....	10
1.2.2.3 Optional Sampling Activities.....	11
1.2.2.4 Investigation-Derived Wastes.....	12
1.2.3 Project Schedule.....	12
1.3 QUALITY OBJECTIVES AND CRITERIA.....	13
1.3.1 Data Quality Objectives.....	13
1.3.2 Measurement Quality Objectives.....	18
1.3.2.1 Precision.....	18
1.3.2.2 Accuracy.....	19
1.3.2.3 Representativeness.....	20
1.3.2.4 Completeness.....	20
1.3.2.5 Comparability.....	20
1.3.2.6 Detection and Quantitation Limits.....	21
1.4 PROJECT ORGANIZATION.....	22
1.5 SPECIAL TRAINING AND CERTIFICATION.....	22
1.5.1 Health and Safety Training.....	22
1.5.2 Subcontractor Training.....	27
1.5.3 Specialized Training and Certification Requirements.....	28

CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
1.6 DOCUMENTS AND RECORDS	28
1.6.1 Field Documentation	28
1.6.2 Preliminary Data Package	28
1.6.3 Full Data Package.....	29
1.6.4 Data Package Format.....	32
1.6.5 Reports Generated	32
2.0 DATA GENERATION AND ACQUISITION.....	33
2.1 SAMPLING PROCESS DESIGN.....	33
2.1.1 Time-Critical Removal Action Sampling Activities	33
2.1.1.1 Delineation of Hot Spots	33
2.1.1.2 Confirmation Sampling	44
2.1.2 Supplemental Sampling Activities	46
2.1.2.1 Other Potential Source Areas	46
2.1.2.2 Groundwater Investigation.....	47
2.1.2.3 Optional Sampling.....	48
2.1.3 Rationale for Selecting Analytical Parameters.....	54
2.1.3.1 Time-Critical Removal Action Sampling Activities	54
2.1.3.2 Supplemental Sampling Activities	54
2.1.3.3 Optional Sampling Activities	55
2.1.3.4 Investigation-Derived Waste.....	55
2.1.4 Surveying	55
2.1.5 Underground Utilities Survey	56
2.2 SAMPLING METHODS	56
2.2.1 Sampling Methods and Equipment	56
2.2.1.1 Soil Sampling for Time-Critical Removal Action, Supplemental Sampling, and Optional Sampling.....	56
2.2.1.2 Supplemental Groundwater Sampling.....	58
2.2.2 Decontamination	61
2.2.3 Management of Investigation-Derived Waste.....	62
2.2.4 Sample Containers and Holding Times.....	62
2.3 SAMPLE HANDLING AND CUSTODY.....	62
2.3.1 Sample Identification	62
2.3.2 Sample Labels	64
2.3.3 Sample Documentation	68
2.3.4 Chain of Custody.....	68
2.3.5 Sample Shipment.....	70
2.4 ANALYTICAL METHODS.....	71
2.4.1 Selection of Analytical Laboratories.....	71
2.4.1.1 Laboratory Evaluation and Prequalification.....	72
2.4.1.2 TtEMI's Government Contracts Basic Ordering Agreement Laboratory Statement of Work.....	72
2.4.1.3 Laboratory Selection and Oversight.....	73
2.4.2 Project Analytical Requirements.....	75

CONTENTS (Continued)

<u>Section</u>		<u>Page</u>
2.5	QUALITY CONTROL	75
2.5.1	Field Quality Control Samples	75
2.5.1.1	Field Duplicates	76
2.5.1.2	Field Blanks	76
2.5.1.3	Trip Blanks	76
2.5.1.4	Equipment Rinsate Samples	77
2.5.1.5	Source Water Blank Samples	77
2.5.2	Laboratory Quality Control Samples	77
2.5.2.1	Method Blanks	77
2.5.2.2	Matrix Spike and Matrix Spike Duplicates	77
2.5.2.3	Laboratory Control Samples or Blank Spikes	78
2.5.2.4	Surrogate Standards	78
2.5.2.5	Internal Standards	78
2.5.3	Additional Laboratory Quality Control Procedures	78
2.5.3.1	Method Detection Limit Studies	79
2.5.3.2	Sample Quantitation Limits	79
2.5.3.3	Control Charts	80
2.6	EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE	80
2.6.1	Maintenance of Field Equipment	80
2.6.2	Maintenance of Laboratory Equipment	81
2.7	INSTRUMENT CALIBRATION AND FREQUENCY	81
2.7.1	Calibration of Field Equipment	81
2.7.2	Calibration of Laboratory Equipment	82
2.8	INSPECTION AND ACCEPTANCE OF SUPPLIES AND CONSUMABLES	82
2.9	NONDIRECT MEASUREMENTS	83
2.10	DATA MANAGEMENT	83
2.10.1	Data-Tracking Procedures	83
2.10.2	Data Pathways	83
2.10.3	Data Management Strategy	84
3.0	ASSESSMENT AND OVERSIGHT	85
3.1	ASSESSMENT AND RESPONSE ACTIONS	85
3.1.1	Field Assessments	85
3.1.2	Laboratory Assessments	86
3.1.3	Assessment Responsibilities	87
3.1.4	Field Corrective Action Procedures	87
3.1.5	Laboratory Corrective Action Procedures	88
3.2	REPORTS TO MANAGEMENT	89
3.2.1	Daily Progress Reports	89
3.2.2	Project Monthly Status Report	89

CONTENTS (Continued)

<u>Section</u>	<u>Page</u>
4.0 DATA VALIDATION AND USABILITY	90
4.1 DATA REVIEW, VERIFICATION, AND VALIDATION	90
4.1.1 Field Data Verification	90
4.1.2 Laboratory Data Verification	90
4.1.3 Laboratory Data Validation	91
4.1.3.1 Cursory Data Validation	91
4.1.3.2 Full Data Validation	91
4.1.3.3 Data Validation Criteria	91
4.2 RECONCILIATION WITH USER REQUIREMENTS	92
REFERENCES	94

Appendix

A	METHOD PRECISION AND ACCURACY GOALS
B	STANDARD OPERATING PROCEDURES
C	FIELD FORMS
D	PROJECT-REQUIRED REPORTING LIMITS
E	APPROVED LABORATORIES
F	EPA METHOD 1669: SAMPLING AMBIENT WATER FOR DETERMINATION OF TRACE METALS AT EPA WATER QUALITY CRITERIA LEVELS

CONTENTS (Continued)

FIGURES

Figure

1	SITE FEATURES MAP	3
2	PROJECT TEAM ORGANIZATION CHART	26
3	HOT SPOT DELINEATION SOIL SAMPLING LOCATIONS	43
4	PROPOSED CINDER EXCAVATION AREA LOCATION	45
5	PROPOSED SAMPLING LOCATIONS IN POTENTIAL SOURCE AREAS.....	50

TABLES

Table

1	ELEMENTS OF EPA QA/R-5 IN RELATION TO THIS SAP	iii
2	IMPLEMENTATION SCHEDULE FOR SAMPLING, ANALYSIS, AND REPORTING.....	13
3	DATA QUALITY OBJECTIVES.....	14
4	QUALITY CONTROL SAMPLES FOR PRECISION AND ACCURACY	18
5	KEY PERSONNEL.....	23
6	REQUIREMENTS FOR FULL DATA PACKAGES	30
7	PROPOSED SAMPLES, RATIONALE, AND ANALYSES	36
8	SUMMARY OF INVESTIGATION AND INVESTIGATION-DERIVED WASTE ANALYSIS	51
9	SAMPLE CONTAINER, HOLDING TIME, AND PRESERVATIVE REQUIREMENTS	65
10	FIELD QUALITY CONTROL SAMPLES	75
11	DATA VALIDATION CRITERIA.....	92

ACRONYMS AND ABBREVIATIONS

AECRU	Indefinite Quantity Contract for Architectural-Engineering Services to Provide CERCLA/RCRA/UST Studies
AOC	Area of concern
bgs	Below ground surface
CCWD	Contra Costa Water District
CFR	Code of Federal Regulations
CLEAN II	Comprehensive Long-Term Environmental Action Navy Contract No. N62474-94-D-7609
CLP	Contract Laboratory Program
CPR	Cardiopulmonary resuscitation
CTO	Contract task order
DHS	California Department of Health Services
DQA	Data quality assessment
DQO	Data quality objective
DTSC	California Environmental Protection Agency Department of Toxic Substances Control
EDD	Electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
ER	Equipment rinsate
FTL	Field team leader
GC/MS	Gas chromatography and mass spectrometry
GPS	Global positioning system
HASP	Health and safety plan
HQ	Hazard quotient
ID	Identification numbers
IDL	Instrument detection limit
IDW	Investigation-derived waste
ICP	Inductively coupled plasma
L	Liter
L/min	Liter per minute
LCS	Laboratory control sample
LIMS	Laboratory information management system
MCAWW	Methods for Chemical Analysis of Water and Waste
MCL	Maximum contaminant level
MDL	Method detection limit
µg/kg	Microgram per kilogram
µg/L	Microgram per liter
mg/kg	Milligrams per kilogram
mL	Milliliter
MS	Matrix spike
MSD	Matrix spike duplicate
MSR	Monthly status report
MQO	Measurement quality objectives

ACRONYMS AND ABBREVIATIONS (Continued)

NEDTS	Navy Environmental Data Transfer Standards
NFESC	Naval Facilities Engineering Service Center
NWSSB	Naval Weapons Station Seal Beach
OSHA	Occupational Safety and Health Administration
PA	Preliminary assessment
PARCC	Precision, accuracy, representativeness, completeness, and comparability
PCB	Polychlorinated biphenyls
PE	Performance evaluation
PPE	Personal protective equipment
PRC	PRC Environmental Management, Inc.
PRG	Preliminary remediation goal
PRRL	Project-required reporting limit
PVC	Polyvinyl chloride
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
%R	Percent recovery
RI	Remedial investigation
RPD	Relative percent difference
RPM	Remedial project manager
RWQCB	Regional Water Quality Control Board
SAP	Sampling and analysis plan
SDG	Sample delivery group
SLERA	Screening-level ecological risk assessment
SOP	Standard operating procedure
SOW	Statement of work
SQL	Sample quantitation limit
SVOA	Semivolatile organic analysis
SVOC	Semivolatile organic compound
SWDIV	Naval Facilities Engineering Command Southwest Division
TCRA	Time-critical removal action
TIC	Tentatively identified compound
TSA	Technical systems audit
TtEMI	Tetra Tech EM Inc.
VOA	Volatile organic analysis
VOC	Volatile organic compound
WET	Waste extraction test

1.0 PROJECT DESCRIPTION AND MANAGEMENT

Tetra Tech EM Inc. (TtEMI) received Contract Task Order (CTO) No. 267 from the Naval Facilities Engineering Command, Engineering Field Activity West (EFA-West), under Comprehensive Long-Term Environmental Action Navy Contract No. N62474-94-D-7609 (CLEAN II). Under CTO No. 267, TtEMI conducted a two-phased preliminary assessment of Site 31 (Area of Concern [AOC] 1) at Naval Weapons Station Seal Beach Detachment Concord (NWSSB Concord) in Concord, California, in two phases. Food-chain modeling conducted during the preliminary assessment (PA) (TtEMI 1999) established that waste materials present at or near the surface at AOC 1 pose an unacceptable risk to ecological receptors. Accordingly, the Navy is conducting a time-critical removal action (TCRA) and supplemental sampling activities to address contaminated materials at AOC 1. To guide the field, laboratory, and data reporting efforts associated with this project, TtEMI prepared this sampling and analysis plan (SAP), which consists of a field sampling plan and a quality assurance project plan (QAPP). This SAP was prepared under CTO No. 267. The TCRA and supplemental sampling will be conducted under Delivery Order (DO) 001 of the Indefinite Quantity Contract for Architectural-Engineering Services to Provide CERCLA/RCRA/UST Studies (AECRU), Contract No. N68711-00-D-0005.

Table 1 follows the approval page at the beginning of this SAP. The table demonstrates how this SAP addresses all elements of a QAPP currently required by the U.S. Environmental Protection Agency (EPA) QA/R-5 guidance document (EPA 2001).

Tables and figures follow the first reference in the text in this document. Appendix A identifies method, precision, and accuracy goals. Appendix B presents standard operating procedures (SOP). Appendix C contains all field forms. Appendix D lists project-required reporting limits, and Appendix E identifies laboratories approved to analyze samples under the AECRU contract. Appendix F lists specific sampling methods required for collecting water samples for low-level mercury analysis.

1.1 PROBLEM DEFINITION AND BACKGROUND

This section describes the following:

- Purpose of the Investigation (Section 1.1.1)
- Problem to be Solved (Section 1.1.2)
- Facility Background (Section 1.1.3)
- Site Description (Section 1.1.4)
- Physical Setting (Section 1.1.5)
- Summary of Previous Investigations (Section 1.1.6)

- Principal Decision Makers (Section 1.1.7)
- Technical or Regulatory Standards (Section 1.1.8)

1.1.1 Purpose of the Investigation

Based on the PA investigation at AOC 1 (TtEMI 1999), the Navy has concluded that a TCRA is warranted to reduce ecological risk associated with metals-contaminated waste material. A map illustrating site features and areas to be addressed by the TCRA is included as Figure 1. In addition, the Navy and regulatory agencies have agreed that supplemental soil and groundwater sampling is required to evaluate areas of the site that have not been investigated during the PA. The purpose of the supplemental soil and groundwater sampling at AOC 1 is to obtain additional soil characterization data to delineate the areas to be addressed by the TCRA and to obtain additional soil and groundwater characterization data to evaluate whether further action is warranted at the site after the TCRA. These data will supplement the information compiled in the PA and PA addendum (TtEMI 2001a) and will be used to evaluate the scope of work necessary to support a remedial investigation at the site after the TCRA.

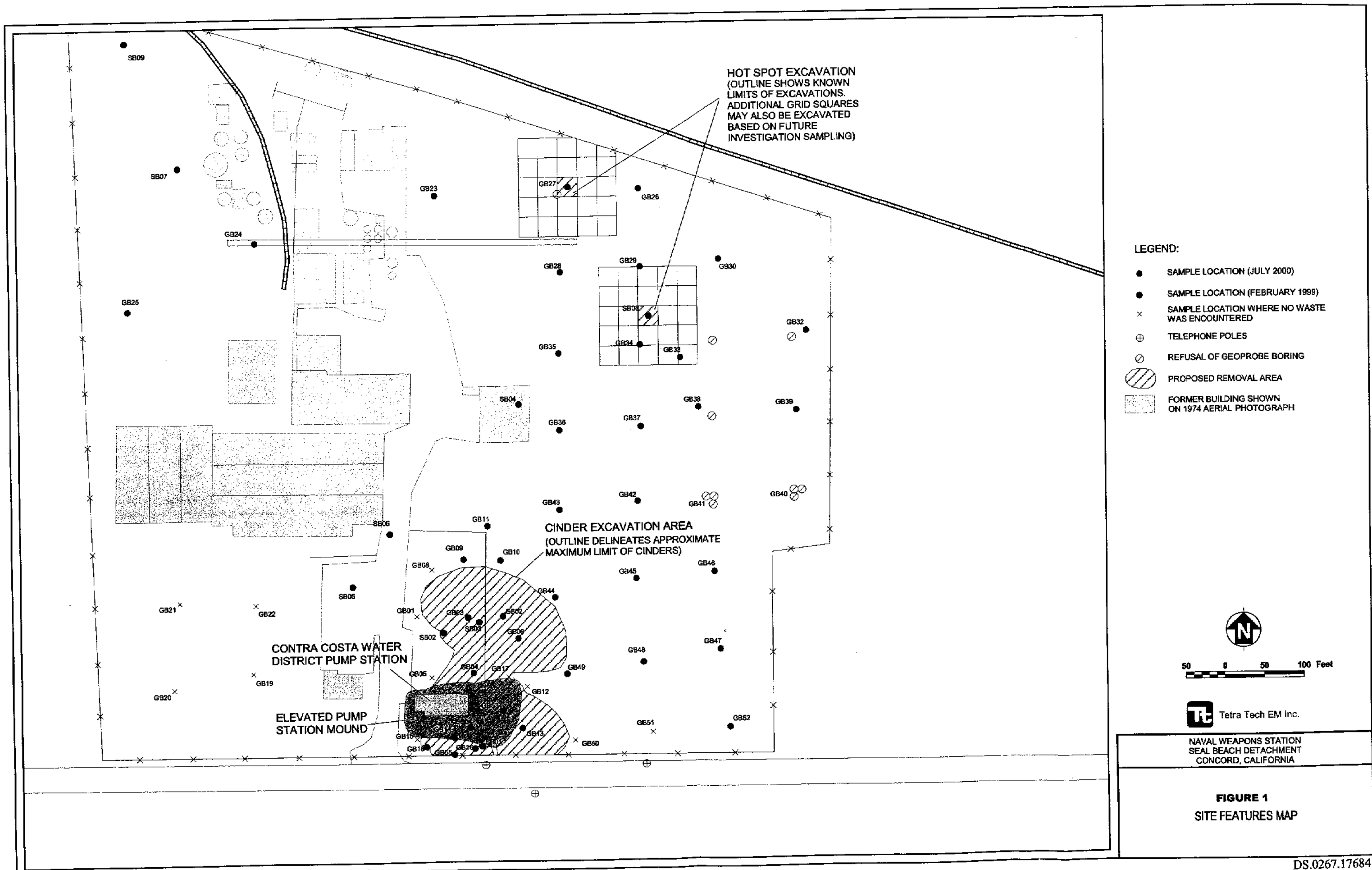
1.1.2 Problem to be Solved

Problems to be solved through the TCRA and supplemental sampling activities are described in the following text.

1.1.2.1 TCRA Sampling Activities

Previous sampling at AOC 1 has shown that waste ash-like material covers the entire eastern half the site. Several areas (hot spots) within this ash-like material contain elevated concentrations of mercury and selenium that pose a threat to ecological receptors. These hot spots will be excavated and removed through the TCRA, but the lateral extent of the area to be excavated has not been adequately defined.

In addition to the ash-like material, cinders in a defined area around the pump station at AOC 1 contain elevated concentrations of mercury and selenium that pose a threat to ecological receptors. Concentrations of lead in the cinders also exceed preliminary remediation goals (PRG) (EPA 2000e); however, unlike the hot spots described above, the lateral extent of cinders can be visually delineated.



The cinders, along with the hot spots described previously, will be excavated and removed through the TCRA. Confirmation samples from the perimeter and bases of all excavations will be taken to demonstrate that the TCRA has effectively removed these materials from the site.

1.1.2.2 Supplemental Sampling Activities

Several potential sources of environmental contamination have not been evaluated at AOC 1 and may pose an ongoing threat to environmental receptors. Soil and waste samples will be collected from possible source areas to evaluate whether the areas pose an unacceptable risk to human and ecological receptors. In addition, groundwater samples will be collected to evaluate whether site-related chemicals may have migrated to and adversely affected groundwater quality at or downgradient from the site. Further, monitoring wells will be installed and groundwater samples will be collected to characterize groundwater quality at the site.

1.1.2.3 Optional Sampling Activities

Although not currently approved by the Navy, additional characterization of potentially contaminated areas may be conducted, as described in this section, to eliminate other potential concerns at AOC 1. Although this work is not yet approved, the additional tasks and analyses described below are included in this SAP for efficiency, should the Navy elect to pursue this optional sampling at AOC 1. The Navy obtained funding for the TCRA and supplemental sampling activities described in this SAP based on regulatory agency requests for additional sampling made at a remedial project managers' (RPM) meeting conducted on December 13, 2001. Regulatory agencies have subsequently requested significant additional sampling, which is described in this document as "optional sampling." Optional sampling will be conducted concurrent with the TCRA sampling and supplemental sampling if the Navy is able to obtain funding for the additional sampling.

- Soil samples may be collected from the spent acid pond area and the area surrounding a former concrete slab to evaluate potential sources of contamination.
- Soil and groundwater samples from supplemental sampling activities may be analyzed for fluoride to evaluate potential fluoride contamination.
- A Geoprobe boring may be advanced 100 feet west of GB43 to evaluate contamination in ash-like material that covers the gridded area over the eastern half of site.
- A fourth new monitoring well may be installed to evaluate groundwater contamination at AOC 1.

1.1.3 Facility Background

NWSSB Concord is located in north-central Contra Costa County, approximately 30 miles northeast of San Francisco, California. NWSSB Concord is a federally owned facility and is currently operated and maintained by the Navy. The primary function of the facility is explosive ordnance transshipment.

1.1.4 Site Description

AOC 1 is an undeveloped 17.2-acre site on Port Chicago Highway, about 1 mile east of the eastern entrance to NWSSB Concord. The site is the former location of a nitrogen-phosphorus-potassium fertilizer plant operated from 1955 to 1976 by Union Oil Company of California. The Navy acquired the property in 1983 to expand the safety buffer for munitions handling at Pier 4. Although all buildings at the site were demolished and removed from the site in 1986, some of the original paved roadways that connected the plant buildings remain. The site is an upland habitat, mostly vegetated with nonnative grasses. The property is currently vacant except for a Contra Costa County pump station and is secured by a locked perimeter fence. Residences and public facilities are present within a 1-mile radius of NWSSB Concord, but no residences or public facilities are located directly adjacent to AOC 1.

1.1.5 Physical Setting

NWSSB Concord includes large tidal wetlands on the south shore of Suisun Bay and several offshore islands that provide the required safety buffer zone for explosives during ship-loading operations. The wetland areas also harbor special-status plants and animals, including the salt marsh harvest mouse (*Reithrodontomys raviventris*), the California black rail (*Laterallus jamaicensis coturniculus*), and the soft bird's beak (*Cordylanthus mollis mollis*). The climate is characterized as semiarid temperate, with rainy winters and dry summers. The average annual precipitation in the area from 1956 to 1974 was 16.5 inches; precipitation occurs mostly between October and March. Regional groundwater near AOC 1 flows north toward Suisun Bay, and groundwater at AOC 1 is expected to occur about 20 feet below ground surface (bgs) in a shallow, unconfined water-bearing zone within the Bay Mud (NFESC 2001).

1.1.6 Summary of Previous Investigations

Between 1973 and 1998, AOC 1 was the subject of a number of investigations by the California Regional Water Quality Control Board (RWQCB), the California Department of Health Services (DHS), and EPA, NWSSB Concord, and Contra Costa Water District (CCWD). However, the actions undertaken by RWQCB, DHS and its successor (the California Environmental Protection Agency Department of Toxic Substances Control [DTSC]), EPA, NWSSB Concord, and CCWD have not addressed the contaminated materials that are the focus of this TCRA.

Previous investigations at AOC 1 are summarized in the December 28, 2001, action memorandum for AOC 1 (NFESC 2001). The Navy first became aware of potential contamination at AOC 1 when the CCWD installed a pump station at the site in 1998 (TtEMI 1999). Samples collected to determine appropriate disposal of excavated soils showed that the soils were contaminated with lead, mercury, and selenium.

The Navy conducted a PA at the site in two phases to further assess the degree of contamination associated with AOC 1 (TtEMI 1999). The first phase, conducted in February 1999, consisted of reviewing agency files about the site and collecting 17 soil samples at nine site locations. The first phase of the PA revealed that the soil contamination affected a larger area than was originally suspected; therefore, the Navy conducted a PA addendum (the second phase) in July 2000 and collected 79 additional soil samples at 28 locations (TtEMI 2001a).

The two-phase PA identified three types of waste materials at the site: (1) cinder roadbed material, (2) ash-like material, and (3) waste gypsum. The cinder roadbed material is contaminated with lead and selenium (up to 11,400 milligrams per kilogram [mg/kg] lead and 875 mg/kg selenium). The ash-like material is contaminated with lead, selenium, and mercury at concentrations up to 895 mg/kg lead, 68.3 mg/kg selenium, and 113 mg/kg mercury. Concentrations of metals are significantly lower in the waste gypsum samples. Organic contaminants were detected inconsistently and at low concentrations in all of the waste materials. Former industrial operations at the site are the suspected source of these waste materials. The cinder roadbed and ash-like materials are the probable waste products from the heat source used to dry and pelletize the fertilizer slurry. Gypsum is a by-product of the fertilizer production process.

Threats to public health or welfare for the industrial use scenario were assessed in the PA addendum using a screening level approach. Cumulative cancer risks for industrial workers (1.1×10^{-4}) slightly exceeded EPA's target risk range. Concentrations of lead significantly exceed the EPA Region 9 PRG for lead (EPA 2000e). Nevertheless, the contaminants at AOC 1 were determined not to pose a threat to human receptors for two reasons. First, access to the site is restricted, and workers visit the site only for occasional maintenance. Second, waste materials at the site are typically covered by vegetation or several inches of topsoil. Therefore, the actual human exposure to contaminants is expected to be significantly lower at AOC 1 than the assumed human exposure used to derive the industrial PRGs.

The Navy has evaluated ecological risks through a screening-level ecological risk assessment (SLERA) and a more focused assessment, which were conducted as part of the PA and presented in the PA addendum. The SLERA used conservative assumptions recommended by EPA (EPA 1999c) for food-chain modeling. Food-chain modeling indicated that arsenic, cadmium, lead, mercury, selenium, and zinc pose an unacceptable risk to the Western meadowlark (*Sturnella neglecta*). Because the SLERA indicated unacceptable risk, the Navy conducted a more focused assessment using more realistic, site-specific and receptor-specific assumptions. Although risk decreased substantially when more realistic assumptions were used for the site, mercury and selenium continued to pose unacceptable risk to the Western meadowlark when more realistic assumptions were used.

In the PA addendum (TtEMI 2001) and at a meeting between the Navy and regulatory agencies on December 13, 2001 (TtEMI 2002b), the Navy proposed to perform a TCRA to excavate and properly dispose of waste materials that contain high concentrations of mercury and selenium to reduce ecological risks at AOC 1. Specifically, the PA addendum proposed excavation and disposal of the cinder roadbed material and two hot spots in the northeast and north-central part of AOC 1 to reduce ecological risks. The Navy's decision to undertake a TCRA for metals-contaminated waste materials at AOC 1 was then documented for the Administrative Record in the December 28, 2001, action memorandum.

In addition, several data gaps were identified at the December 13, 2001, meeting (TtEMI 2002b). Specifically, several potential sources of environmental contamination have not been evaluated, and no groundwater monitoring has been conducted on site to determine whether site-related chemicals may have migrated and adversely affected groundwater at or down gradient of the site. As a result, the Navy intends to conduct supplemental sampling to address these data gaps, as described subsequently in this SAP.

1.1.7 Principal Decision Makers

Principal decision makers include the Navy, regulatory agencies (EPA Region 9, DTSC, and RWQCB), and the public. These decision makers will use the data collected from this project in conjunction with data generated during previous investigations to evaluate whether additional work is required at AOC 1.

1.1.8 Technical or Regulatory Standards

The Navy intends to use promulgated regulatory standards to assess risk to humans and the more focused food-chain model presented in the PA addendum (TtEMI 2001a) and other promulgated standards to

assess risks to ecological receptors. For the TCRA sampling activities, hazard quotients (HQ) greater than 1.0 will be considered to present unacceptable ecological risks. For supplemental sampling of soils at other potential source areas, EPA Region 9 PRGs for industrial soil (EPA 2002a) and HQs less than 1.0 will be the regulatory criteria applied to assess human health and ecological risk, respectively. To assess human health risk, metal concentrations in groundwater samples will be compared with EPA Region 9 PRGs for tap water (EPA 2002a) and EPA maximum contaminant levels (MCL) (EPA 2002b). These metal concentrations will also be compared with EPA's national recommended water quality criteria (NRWQC) (EPA 2002c), EPA's State of California water quality criteria (California Toxics Rule), and the Bay Basin's plan objectives upstream of San Pablo Bay (RWQCB 1995) to assess ecological risk.

1.2 PROJECT DESCRIPTION

The following subsections discuss the objectives, measurements, and schedule for the project.

1.2.1 Project Objectives

The objective of this investigation is to obtain the additional contamination data for soil and groundwater that is needed to define the soil removal areas for the TCRA and to evaluate whether further action is warranted for the site after the TCRA. The following field activities will be carried out at AOC 1 to meet these objectives:

1.2.1.1 TCRA Sampling Activities

- Collect and analyze (for total metals) additional soil samples in the ash-contaminated part of the site from the area surrounding each of the two previously identified hot spots to better define the lateral limits.
- Once the removal of contaminated soil is completed, collect and analyze (for total metals) confirmation samples around the perimeter of the excavations and throughout the footprint of the excavation to verify that the removal action has addressed ecological risks at AOC 1.

1.2.1.2 Supplemental Sampling Activities

- Collect and analyze soil samples from areas where historical maps show former locations of industrial processes, including the former laboratory, former warehouse area, former process tanks (east and west of central road), and along the northern boundary of the site to assess whether these potential source areas pose an ongoing threat to human or environmental receptors. In addition, a maximum of three discrete samples will be collected from each of three boreholes drilled 100 feet west of the soil-sampling grid

established during the PA to extend the gridded sampling area over the part of the site that has not yet been sampled.

- Install and sample three monitoring wells to determine the direction of groundwater flow and to assess groundwater quality.

No groundwater or soil in these potential source areas at the site have been collected and analyzed.

Therefore, soil samples collected during supplemental sampling activities will be analyzed for a comprehensive list of chemicals, including metals, VOCs, SVOCs, pesticides, PCBs, and chlorinated herbicides. Existing soil data indicate that VOCs, pesticides, PCBs, and chlorinated herbicides are only present at trace concentrations in site soils, and as a result, groundwater samples will be analyzed for metals, SVOCs, total suspended solids (TSS), and total dissolved solids (TDS). If analytical results from soil samples at new potential source areas indicate that other organic compounds are present at concentrations that may affect groundwater, groundwater samples will be analyzed for other organic compounds detected in site soils.

1.2.1.3 Optional Sampling Activities

Although additional borings, wells, and analyses are not currently approved by the Navy, additional sampling may include:

- Collect and analyze soil samples from spent acid pond area and area surrounding a former concrete slab to evaluate potential sources of contamination.
- Analyze groundwater samples for fluoride to evaluate potential fluoride contamination.
- A Geoprobe boring may be advanced 100 feet west of GB43 to evaluate contamination in ash-like material that covers gridded area over eastern half of site.
- A fourth new monitoring well may be installed to evaluate groundwater contamination at AOC 1.

No soil samples have been collected and analyzed from the expected base of the spent acid pond, the former concrete slab, or 100 feet west of GB43. Therefore, soil samples collected during optional supplemental sampling activities will be analyzed for a comprehensive list of chemicals, including metals, VOCs, SVOCs, pesticides, PCBs, and chlorinated herbicides.

1.2.2 Project Measurements

Project measurements for the TCRA, for the supplemental sampling activities, and for investigation-derived waste (IDW) are discussed in the following text.

1.2.2.1 TCRA Sampling Activities

To better define the lateral limits of the hot spots, Geoprobe soil borings will be advanced from 0 to 3 feet bgs in the area surrounding each of the two hot spots, as described in Section 2.1.1. Soil samples will be collected from each 0.5-foot interval that contains waste materials or have other visual evidence of contamination. If no waste material or visual evidence of contamination is apparent, soil samples will be collected from the surface to 0.5-foot depth interval of the soil boring. These soil samples will be analyzed for lead, mercury, and selenium.

Once soil removal is complete, confirmatory soil samples will be collected from around the perimeter of the excavations and throughout the footprint of the excavations from the initial 6 inches of soil. These soil samples will be analyzed for lead, mercury, and selenium.

1.2.2.2 Supplemental Sampling Activities

To characterize potential source areas, including the former laboratory, former warehouse area, and former process tanks, and to assess potential runoff along the northern boundary of the site, Geoprobe soil borings will be advanced from 0 to 6 feet bgs at each potential source area and at the northern boundary of AOC 1. Soil samples will be collected from waste material or visibly contaminated intervals, directly beneath the waste material, and 2 feet beneath the bottom of the waste or visible contamination. If no waste material or visible contamination is apparent in the soil borings, soil samples will be collected from the 0 to 0.5 foot bgs, 3 to 3.5 feet bgs, and 5.5 to 6 feet bgs intervals. These soil samples will be analyzed for metals, semivolatile organic compounds (SVOC), pesticides, polychlorinated biphenyls (PCB), and chlorinated herbicides. In addition, any sample collected from a depth interval more than 1 foot from the surface will be analyzed for volatile organic compounds (VOC).

Groundwater samples will be collected from monitoring wells to be installed at locations selected to determine the direction of groundwater flow and to evaluate potential sources of contamination.

Regulatory agencies have specifically asked to participate in the selection of monitoring well locations. Well locations will be selected in consultation with the regulatory agencies after the analytical results from other potential sources are available. At minimum, one upgradient well near the southern boundary of the site and two wells downgradient from potential sources of contamination will be installed.

Potential monitoring well locations include an upgradient well in the southwest corner of the site and downgradient wells south of the cinder excavation, hot spot excavation area, and the former spent acid pond. The groundwater samples will be analyzed for metals, SVOCs, TSS, and TDS only, unless sources of VOCs, pesticides, PCBs, or chlorinated herbicides are discovered in nearby soils, in which case groundwater will be analyzed for the other compounds found in nearby soils. No significant sources of organic compounds have been discovered in sampling conducted to date.

1.2.2.3 Optional Sampling Activities

To characterize other potential source areas, the Navy may elect to collect samples at the spent acid pond, concrete slab, 100 feet west of location GB43, and other potential source areas not yet identified. At the spent acid pond, the Navy will advance one boring to 20 feet bgs; collect discrete samples at any soil interval showing evidence of contamination, directly beneath the interval, and 2 feet beneath the base of the interval. Lacking evidence of contamination, the Navy will collect samples from 9 to 9.5 ft, 12 to 12.5 ft, and 15 to 15.5 ft bgs. The depth of the bottom of the former pond is unknown; the sampling intervals noted above are intended to span the likely interval of the bottom of the pond. A shallow soil interval (4 to 4.5 feet bgs) at this location was tested in the PA. These soil samples will be analyzed for pH and a comprehensive list of chemicals, including metals, VOCs, SVOCs, pesticides, PCBs, and chlorinated herbicides.

At the concrete slab, four Geoprobe borings will be advanced (one on each of the four sides of the slab). Each boring will be located near the mid-point of the side and in the soil surrounding the slab at about 1 foot from the edge of the slab. The borings will be advanced from 0 to 3 feet bgs in 0.5-foot intervals. Discrete samples will be collected from any soil interval showing evidence of contamination, then a composite sample will be created by mixing equal portions of the discrete samples from each side. The composite sample will be analyzed for metals, pesticides, herbicides, SVOCs. Lacking evidence of contamination, the samples will be collected from 0 to 0.5 feet bgs. Each discrete soil sample that makes up the composite sample will be scanned with a photoionization detector (PID) as soon as the acetate sample sleeve is cut away to assess the presence of VOCs. If the PID indicates that VOCs are present in any discrete sample, the interval showing the highest VOC concentrations on the PID will be sampled for VOCs. Lacking any evidence of the presence of VOCs, the field sampler will collect a single discrete sample for VOC analysis from the soil interval most likely to be contaminated based on discoloration or other visual or olfactory cues.

At a location approximately 100 feet west of GB43, the Navy may advance a Geoprobe boring to a depth of 6 feet bgs to extend the gridded area to encompass the entire western half of the site. Ash-like material is present at this location. The Navy will collect samples of the waste material, soils directly beneath the waste material, and soils 2 feet beneath the bottom of the waste. Samples from this boring will be analyzed for a comprehensive list of chemicals, including VOCs, SVOCs, metals, pesticides, PCBs, and chlorinated herbicides.

A fourth monitoring well may be installed to evaluate groundwater contamination at AOC 1. A groundwater sample from this well will be analyzed for metals, SVOCs, TSS, and TDS. If nearby soils

indicate that other organic compounds are present at concentrations that may affect groundwater, groundwater samples will be analyzed for other organic compounds present in nearby soils.

If appropriate, soil samples and one round of groundwater samples from supplemental sampling activities will be analyzed for fluoride, and the results will be compared with regulatory criteria to address agency concerns that the phosphoric acid wet process that appears to have been used at the fertilizer plant may have contaminated soil and groundwater with unsafe concentrations of fluoride.

1.2.2.4 Investigation-Derived Wastes

IDW will be produced during the TCRA and supplemental sampling activities. Soil IDW will be sampled and analyzed for VOCs, SVOCs, pesticides, PCBs, chlorinated herbicides, reactivity, ignitability, pH, and toxicity characteristic leaching procedure (TCLP) and waste extraction test (WET) metals. Groundwater from developing and purging new monitoring wells and water from decontamination will be containerized in 55-gallon drums and will be sampled and analyzed for the following suite of analytes: VOCs, SVOCs, pesticides, PCBs, chlorinated herbicides, metals, flash point, and pH. All samples will be analyzed at an off-site laboratory.

1.2.3 Project Schedule

Table 2 presents a project schedule.

TABLE 2
IMPLEMENTATION SCHEDULE FOR SAMPLING, ANALYSIS, AND REPORTING

Milestone	Due Date	Anticipated Date
Internal Draft SAP to Navy	May 3, 2002	May 20, 2002
Draft SAP to Agencies	7 calendar days after Navy comments are received	May 24, 2002
Agency review period	1 month (if expedited review is accepted)	June 21, 2002
Internal Final SAP to Navy	21 calendar days after all regulatory agency comments are received	August 16, 2002
Final SAP to Regulatory Agencies	7 calendar days after Navy comments are received	August 23, 2002
HASP to Navy	7 calendar days before field investigation begins	May 24, 2002
Field investigation	45 calendar days after all regulatory agency comments are received (agency approval of SAP not required for TCRA hot spot delineation sampling)	October 7, 2002
Begin TCRA	June 28, 2002	June 28, 2002

Notes:

HASP	Health and safety plan
SAP	Sampling and analysis plan
TCRA	Time-critical removal action

1.3 QUALITY OBJECTIVES AND CRITERIA

The following sections present the data quality objectives (DQO) and measurement quality objectives (MQO) identified for this project.

1.3.1 Data Quality Objectives

DQOs are qualitative and quantitative statements developed through the seven-step DQO process (EPA 2000b, 2000d). The DQO process helps clarify the study objective, define the most appropriate data to collect and the conditions under which to collect the data, and specify tolerable limits on decision errors to be used as the basis for establishing the quantity and quality of data needed to support decision-making. The DQO process is used to develop a scientific and resource-effective design for data collection. The seven steps of the DQO process for this project are presented in Table 3.

TABLE 3

DATA QUALITY OBJECTIVES FOR FIELD SAMPLING TO SUPPORT TIME-CRITICAL REMOVAL ACTION AT AREA OF CONCERN 1 (SITE 31)
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
State the Problem	Identify the Decisions	Identify the Inputs to the Decisions	Define Study Boundaries	Develop Decision Rules	Specify Tolerable Limits on Errors	Optimize Sampling Design
Delineation of Hot Spots, Excavation of Metals-Contaminated Materials, and Confirmation Sampling						
<p>Previous sampling has shown that waste ash-like material covers the entire eastern half of AOC 1. Several hot spots within this ash-like material contain elevated concentrations of mercury and selenium that pose a threat to ecological receptors. The contaminated materials in these hot spots will be excavated and removed through a TCRA, but the lateral extent of the area to be excavated has not been adequately defined.</p> <p>In addition to the ash-like material, cinders in a defined area around the pump station are also contaminated with elevated concentrations of mercury and selenium that pose a threat to ecological receptors. Concentrations of lead in the cinders also exceed industrial PRGs; however, unlike the hot spots, the lateral extent of cinders can be visually delineated. The cinders, along with the hot spots described above, will be excavated and removed through a TCRA. Confirmation samples from the perimeter and bases of all excavations are required to demonstrate that the TCRA has effectively removed metals-contaminated materials from the site.</p>	<p>1. Do contaminated soils at hot spots centered at sampling locations GB27 and SB08 extend beyond the proposed 25' x 25' areas of excavation and, if so, what is the lateral extent of contamination that poses an unacceptable ecological risk?</p> <p>2. Do confirmation samples collected from the perimeter of the cinder removal area contain concentrations of mercury and selenium that pose an unacceptable risk to ecological receptors?</p> <p>3. Do confirmation samples collected from the perimeter of the cinder removal area contain concentrations of lead that exceed industrial PRGs?</p>	<ul style="list-style-type: none"> Existing analytical data for metals in soil samples collected in a grid around the hot spots Validated and defensible analytical data for metals (specifically Hg and Se) in composite soil samples collected from grid squares that surround the hot spots located at GB27 and SB08 Recalculated HQs from focused risk assessment using new data on metals concentrations in shallow soils in the area surrounding the existing hot spot samples. Field observations of the lateral extent of cinders Analytical data for metals in confirmation samples Parameters and equations used in the food-chain model 	<ul style="list-style-type: none"> Lateral boundary of hot spots includes the area within 5 x 5 grid of 25-ft squares centered on sample locations GB27 and SB08. Lateral boundary of cinder excavation area includes the area near CCWD pump station (see Figure 3). Vertical boundary of excavations is the bottom of the waste or 2 ft bgs, whichever is deeper Temporal boundary: Soil removal must begin by June 28, 2002, to meet requirements of TCRA. 	<p>1a. If analytical results from the soil samples collected from 25' x 25' grid squares that surround locations GB27 and SB08 indicate that metals-contaminated materials that pose an unacceptable ecological risk extend beyond the proposed excavation area, then the area of excavation will be extended and additional step-out samples will be collected around the extended area of excavation.</p> <p>1b. If analytical results from the soil samples collected from 25' x 25' grid squares that surround locations GB27 and SB08 indicate that metals-contaminated materials that pose an unacceptable ecological risk do not extend beyond the proposed excavation area, then the excavation areas will not be extended.</p> <p>2a. If confirmation samples collected from the perimeter of the cinder removal area contain concentrations of metals that pose an unacceptable ecological risk, then the need for additional site characterization or removal actions will be addressed under a separate study.</p> <p>2b. If confirmation samples collected from the perimeter of the cinder removal area contain concentrations of metals that do not pose an unacceptable ecological risk, then the cinder removal action will be complete.</p> <p>3a. If confirmation samples collected from the perimeter of the cinder removal area contain concentrations of lead that exceed industrial PRGs, then the need for additional site characterization or removal actions will be addressed under a separate study.</p> <p>3b. If confirmation samples collected from the perimeter of the cinder removal area do not contain concentrations of lead that exceed industrial PRGs, then the cinder removal action will be complete.</p>	<p>Rather than using a formal statistical test with designated error rates, this action will use revised UCL₉₅ for metals concentrations in surface soil (0 to 2 feet bgs) to recalculate HQs. Data for the new delineation samples will be added to the data set and data for the area to be excavated will be subtracted to calculate a new UCL₉₅ that represents remaining soils at AOC 1. These data will be input into the existing focused food chain model presented in the Addendum to the PA (TtEMI 2001) to evaluate ecological risk for the soils remaining after excavation. Output from the model will be used to decide whether the removal actions have reduced ecological risk to acceptable levels (HQs less than 1.0).</p> <p>MQOs are established in Section 1.3.2 of the SAP and will be used to assess the quality of analytical data. Reporting limits will be confirmed to be less than action limits, or rationale will be provided if not.</p>	<p>The central grid square is assumed to require excavation and removal. Composite soil samples will be collected from grid squares that are contiguous with the central square, and the need for excavation and removal of these contiguous grid squares will be assessed.</p> <p>Four individual samples will be combined to make a composite sample from each contiguous grid square. Each grid square will be divided into four smaller squares, and the individual samples will be collected from the center of each smaller square so that the each sample represents an equal area.</p> <p>If the HQ for any metal exceeds 1, then the grid square represented by these samples will be slated for excavation and grid squares surrounding those additional squares (second-tier grid squares) will be sampled in the same manner. New UCL₉₅ soil concentrations representing materials that will remain at the site will be calculated, and the food chain model will be run again. This iterative procedure will be used to delineate and excavate metals-contaminated soil that poses an unacceptable ecological risk.</p> <p>Due to budgetary constraints, sampling and excavation beyond the second-tier grid squares will not be conducted under the TCRA.</p>

TABLE 3 (Continued)

DATA QUALITY OBJECTIVES FOR FIELD SAMPLING TO SUPPORT TIME-CRITICAL REMOVAL ACTION AT AREA OF CONCERN 1 (SITE 31)

NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
State the Problem	Identify the Decisions	Identify the Inputs to the Decisions	Define Study Boundaries	Develop Decision Rules	Specify Tolerable Limits on Errors	Optimize Sampling Design
Investigative sampling of soils at other potential source areas						
<p>Several potential sources of environmental contamination have not been evaluated and contaminated soils may pose an ongoing threat to environmental receptors. Judgmentally located samples of soils and waste will be collected from possible source areas to evaluate whether the areas pose an unacceptable risk to human and ecological receptors.</p>	<ul style="list-style-type: none"> Are site-related contaminants present in the following potential source areas at concentrations that pose an unacceptable ecological or human health risk? <ul style="list-style-type: none"> Laboratory Warehouse area Process tanks east and west of central road Northern boundary of site Three boreholes drilled 100 feet west of existing grid 	<ul style="list-style-type: none"> Validated and defensible analytical data for metals and organic compounds in samples of soil and waste materials. Parameters and equations used in the food-chain model Industrial PRGs Professional judgment 	<ul style="list-style-type: none"> Lateral boundary of AOC 1 is the area bounded by the existing perimeter fence. Vertical boundary extends from 0 to 6 ft bgs. Investigative work at AOC 1 is not part of the TCRA, so temporal boundary for this work is not constrained by TCRA or other requirements. 	<p>If site-related contaminants are present in potential source areas at concentrations that pose an unacceptable risk to ecological receptors, then additional characterization of the nature and extent of contamination will be recommended for a follow-on study.</p> <p>If site-related contaminants are not detected in potential source areas or if they are present at concentrations that do not pose an unacceptable risk to human health and ecological receptors, then no additional work will be recommended.</p> <p>If UCL₉₅ concentrations of site-related contaminants exceed industrial PRGs, then the need for a more formal human health risk assessment will be evaluated.</p> <p>If UCL₉₅ concentrations of site-related contaminants do not exceed industrial PRGs, then further evaluation of human health risk will not be recommended.</p>	<p>Sampling locations for this task will be selected using professional judgment; so formal statistical tests will not be conducted. Rather than using a formal statistical test with designated error rates, this action will use revised UCL₉₅ for contaminant concentrations in site samples to evaluate ecological and human health risks. The UCL₉₅ concentrations will be compared with industrial PRGs for soil to assess human health risk. The UCL₉₅ concentrations will be input into the existing focused food chain model presented in the Addendum to the PA (TtEMI 2001) to evaluate ecological risk posed by soils and waste materials in the potential source areas. Output from the model will be used to decide whether the removal actions have reduced ecological risk to acceptable levels (HQs less than 1.0).</p> <p>MQOs are established in Section 1.3.2 of the SAP and will be used to assess the quality of analytical data. Detection limits will be confirmed to be less than action limits, or rationale will be provided if not. Output from the model will be used to decide whether the removal actions have reduced ecological risk to acceptable levels (HQs less than 1.0).</p>	<p>Investigative samples of soil will be collected from the vicinity of the former laboratory, former warehouse area, former process tanks (east and west of the central road), and along the northern boundary of the site. In addition, a maximum of three discrete samples will be collected from each of three boreholes drilled 100 feet west of the existing sampling grid.</p> <p>Three discrete samples of soil will be collected at the former laboratory. One composite sample per area will be collected from the warehouse area, the northern boundary, and at each of the process tank areas.</p> <p>Results for these investigative samples will be reported under this task; however, due to budgetary constraints, additional site characterization or removal actions (if necessary) will be addressed under a separate study.</p>

TABLE 3 (Continued)

DATA QUALITY OBJECTIVES FOR FIELD SAMPLING TO SUPPORT TIME-CRITICAL REMOVAL ACTION AT AREA OF CONCERN 1 (SITE 31)
NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
State the Problem	Identify the Decisions	Identify the Inputs to the Decisions	Define Study Boundaries	Develop Decision Rules	Specify Tolerable Limits on Errors	Optimize Sampling Design
Groundwater sampling						
Groundwater occurs approximately 20 feet bgs at the site; however, there are no monitoring wells and samples of groundwater have never been collected to evaluate whether site-related chemicals may have migrated to and adversely affected the quality of groundwater at or downgradient from the site.	Are concentrations of site-related chemicals present in site groundwater at concentrations that pose an unacceptable risk to human or ecological receptors?	<p>Validated and defensible analytical data for metals, total suspended solids, and organic compounds in samples of groundwater</p> <p>Risk-based concentrations such as U.S. EPA Region IX tap water PRGs, MCLs, and Concord Water Screening values</p> <p>Groundwater elevations in new monitoring wells to be installed at AOC 1.</p> <p>TSS and TDS concentrations to evaluate groundwater potability and metals partitioning</p>	<ul style="list-style-type: none"> ▪ Lateral boundary of AOC 1 is the area bounded by the existing perimeter fence. ▪ Vertical boundary extends from the ground surface to groundwater, which is expected to occur at 20 feet bgs ▪ Investigative work at AOC 1 is not part of the TCRA, so temporal boundary for this work is not constrained by TCRA or other requirements. 	<p>If site-related chemicals are present at concentrations that exceed risk-based concentrations, then additional characterization may be recommended and background concentrations may need to be established.</p> <p>If site-related chemicals are not present at concentrations that exceed risk-based concentrations, then no further action is needed for groundwater.</p>	<p>The locations of monitoring wells will be selected using professional judgment in consultation with the regulatory agencies.</p> <p>Concentrations of metals and organic compounds will be evaluated with respect to levels of TSS to ensure that data reflect the composition of groundwater rather than the composition of suspended particulates contained in the sample.</p> <p>MQOs are established in Section 1.3.2 of the SAP and will be used to assess the quality of analytical data. Detection limits will be confirmed to be less than action limits, or rationale will be provided if not. (In this case, detection limits must be lower than PRGs for tap water and Concord water screening values.)</p>	Monitoring wells will be installed at locations selected to facilitate determination of the direction of groundwater flow and to evaluate potential sources of contamination.

TABLE 3 (Continued)

DATA QUALITY OBJECTIVES FOR FIELD SAMPLING TO SUPPORT TIME-CRITICAL REMOVAL ACTION AT AREA OF CONCERN 1 (SITE 31)

NAVAL WEAPONS STATION SEAL BEACH DETACHMENT CONCORD

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
State the Problem	Identify the Decisions	Identify the Inputs to the Decisions	Define Study Boundaries	Develop Decision Rules	Specify Tolerable Limits on Errors	Optimize Sampling Design
Optional Sampling						
<p>Other potential sources have not been fully investigated.</p> <p>Fluoride may be a contaminant of concern</p>	<ul style="list-style-type: none"> Are site-related contaminants present in the following potential source areas at concentrations that pose an unacceptable ecological or human health risk? <ul style="list-style-type: none"> Former spent acid pond Concrete slab 100 ft west of GB43 Is fluoride present in potential source areas at concentrations that pose an unacceptable ecological or human health risk? 	<ul style="list-style-type: none"> Validated and defensible analytical data for metals, organic compounds (at concrete slab only) and fluoride in samples of soil and waste materials. Parameters and equations used in the food-chain model Industrial PRGs Professional judgment 	<ul style="list-style-type: none"> Lateral boundary of AOC 1 is the area bounded by the existing perimeter fence. Vertical boundary extends from 0 to 20 ft bgs. Investigative work at AOC 1 is not part of the TCRA, so temporal boundary for this work is not constrained by TCRA or other requirements. 	<p>If site-related contaminants are present in potential source areas at concentrations that pose an unacceptable risk to ecological receptors, then additional characterization of the nature and extent of contamination will be recommended for a follow-on study.</p> <p>If site-related contaminants are not detected in potential source areas or if they are present at concentrations that do not pose an unacceptable risk to human health and ecological receptors, then no additional work will be recommended.</p> <p>If UCL₉₅ concentrations of site-related contaminants exceed industrial PRGs, then the need for a more formal human health risk assessment will be evaluated.</p> <p>If UCL₉₅ concentrations of site-related contaminants do not exceed industrial PRGs, then further evaluation of human health risk will not be recommended.</p>	<p>Sampling locations for this task will be selected using professional judgment; so formal statistical tests will not be conducted. Rather than using a formal statistical test with designated error rates, this action will use revised UCL₉₅ for contaminant concentrations in site samples to evaluate ecological and human health risks. The UCL₉₅ concentrations will be compared with industrial PRGs for soil to assess human health risk. The UCL₉₅ concentrations will be input into the existing focused food chain model presented in the Addendum to the PA (TtEMI 2001) to evaluate ecological risk posed by soils and waste materials in the potential source areas. Output from the model will be used to decide whether the removal actions have reduced ecological risk to acceptable levels (HQs less than 1.0).</p> <p>MQOs established in Section 1.3.2 of the SAP will be used to assess the quality of analytical data. Detection limits will be confirmed to be less than action limits, or rationale will be provided if not.</p>	<p>One boring will be advanced to a depth of 20 feet through the center of the former spent acid pond. Three discrete samples will be collected from the soil interval at and beneath the base of the former pond, as indicated by discoloring or other evidence of contamination. Lacking such evidence, the samples will be collected at 9, 12, and 15 feet below grade.</p> <p>Four borings will be advanced to a depth of 3 feet bgs in soils around the perimeter of the concrete slab, with one boring near the center of each side of the slab. Soil samples from any soil interval showing evidence of contamination, or from 0 to 0.5 feet if such evidence is lacking, will be combined to create a single composite sample.</p> <p>Fluoride may be added to the list of analytes for the samples described under investigative sampling and groundwater sampling.</p>

Notes:

Concord Water Screening values are based on are based on EPA National Water Quality Criteria (EPA 1998, 1999), the California Toxics Rule, and the Bay Basin Plan Upstream of San Pablo Bay (RWQCB 1995).

AOC	Area of Concern	PRG	Preliminary remediation goal
bgs	Below ground surface	TCRA	Time-critical removal action
CCWD	Contra Costa Water District	TDS	Total dissolved solids
HQ	Hazard quotient	TSS	Total suspended solids
MCL	Maximum contaminant level		

1.3.2 Measurement Quality Objectives

All analytical results will be evaluated in accordance with precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters to document the quality of the data and to ensure that the data are of sufficient quality to meet the project objectives. Of these PARCC parameters, precision and accuracy will be evaluated quantitatively by collecting the quality control (QC) samples listed in Table 4. Specific precision and accuracy goals for these QC samples are listed in Appendix A.

TABLE 4
QUALITY CONTROL SAMPLES FOR PRECISION AND ACCURACY

QC Type	Precision	Accuracy	Frequency
Field QC	Field Duplicate RPD	Field Blanks Equipment Rinsate Trip Blanks	Field Duplicate = 1/10 samples (groundwater only) Equipment Rinsate = 1/day/piece of equipment Trip Blank = 1/sample cooler (if containing samples to be analyzed for VOCs)
Laboratory QC	MS/MSD RPD	MS/MSD %R LCS or Blank Spikes Field Duplicate Surrogate Standards %R Internal Standards %R	MS/MSD = 1/20 samples LCS or Blank Spikes = 1/20 samples Field duplicate = 1/10 samples (groundwater only) Every sample (VOCs and SVOCs) Every sample (VOCs and SVOCs)

Notes:

%R	Percent recovery
LCS	Laboratory control sample
MS/MSD	Matrix spike and matrix spike duplicate
RPD	Relative percent difference
QC	Quality control
VOC	Volatile organic compound

The subsections below describe each of the PARCC parameters and how they will be assessed within this project.

1.3.2.1 Precision

Precision is the degree of mutual agreement between individual measurements of the same property under similar conditions. Usually, combined field and laboratory precision is evaluated by collecting and

analyzing field duplicates and then calculating the variance between the samples, typically as a relative percent difference (RPD).

$$RPD = \frac{|A - B|}{(A + B)/2} \times 100\%$$

where

A = first duplicate concentration

B = second duplicate concentration

Field sampling precision is evaluated by analyzing field duplicate samples. Because soil and waste materials are very heterogeneous, it is very difficult to obtain two identical samples for duplicates; therefore, field duplicates of soil and waste will not be collected for this investigation. Field duplicate samples will be collected for groundwater.

Laboratory analytical precision is evaluated by analyzing laboratory duplicates or matrix spikes (MS) and matrix spike duplicates (MSD). For this project, MS/MSD samples will be generated for all analytes. The results of the analysis of each MS/MSD pair will be used to calculate an RPD for evaluating precision.

1.3.2.2 Accuracy

A program of sample spiking will be conducted to evaluate laboratory accuracy. This program includes analysis of the MS and MSD samples, laboratory control spikes (LCS) or blank spikes, surrogate standards, and method blanks. MS and MSD samples will be prepared and analyzed at a frequency of 5 percent for soil and groundwater samples. LCS or blank spikes are also analyzed at a frequency of 5 percent. Surrogate standards, where available, are added to every sample analyzed for organic constituents. The results of the spiked samples are used to calculate the percent recovery for evaluating accuracy.

$$\text{Percent Recovery} = \frac{S - C}{T} \times 100$$

where

S = Sample concentration (after spiking)

C = Sample concentration (before spiking)

T = True or actual concentration of the spike

Appendix A presents accuracy goals for the investigation based on the percent recovery of matrix and surrogate spikes. Results that fall outside the accuracy goals will be further evaluated on the basis of the results of other QC samples.

1.3.2.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a population, variations in a parameter at a sampling point, or an environmental condition that they are intended to represent. For this project, representative data will be obtained through careful selection of sampling locations and analytical parameters. Representative data will also be obtained through proper collection and handling of samples to avoid interference and minimize contamination.

Representativeness of data will also be ensured through the consistent application of established field and laboratory procedures. Field (if conditions during sampling render collection of these samples necessary) and laboratory blank samples will be evaluated for the presence of contaminants to aid in evaluating the representativeness of the sample results. Data determined to be nonrepresentative by comparison with existing data will be used only if accompanied by appropriate qualifiers and limits of uncertainty.

1.3.2.4 Completeness

Completeness is a measure of the percentage of project-specific data that are valid. Valid data are obtained when samples are collected and analyzed in accordance with QC procedures outlined in this SAP and when none of the QC criteria that affect data usability are exceeded. When all data validation is completed, the percent completeness value will be calculated by dividing the number of useable sample results by the total number of sample results planned for this investigation.

As discussed further in Section 4.2, completeness will also be evaluated as part of the data quality assessment process (EPA 2000c). This evaluation will help determine whether any limitations are associated with the decisions to be made based on the data collected.

1.3.2.5 Comparability

Comparability expresses the confidence with which one data set can be compared with another. Comparability of data will be achieved by consistently following standard field and laboratory procedures and by using standard measurement units in reporting analytical data.

1.3.2.6 Detection and Quantitation Limits

The method detection limit (MDL) is the minimum concentration of an analyte in a standard solution that can be reliably distinguished from background noise for a specific analytical method. The quantitation limit represents the lowest concentration of an analyte that can be accurately and reproducibly quantified in a sample matrix. Project required reporting limits (PRRL) are contractually specified maximum quantitation limits for specific analytical methods and sample matrices, such as soil or water, and are typically several times higher than the MDL to allow for matrix effects. PRRLs, which are established by TtEMI in the scope of work for subcontracted laboratories, are set liberally to establish minimum criteria for laboratory performance; actual laboratory quantitation limits may be substantially lower.

For this project, analytical methods have been selected so that the PRRL for each target analyte is below the regulatory criteria, wherever practical. In addition, the Navy has determined that the PRRLs for the selected analytical methods are low enough to allow calculation of an HQ less than 1.0. Appendix D compares the PRRLs for the selected analytical methods with the regulatory criteria. This comparison shows that the selected analytical methods and associated PRRLs are capable of quantifying contaminants of concern at concentrations below the regulatory criteria.

For soils, the PRRLs for several organic compounds exceeded one or more regulatory criteria. These few exceptions have been judged to be acceptable for the following reasons:

- The PRRL reflects the maximum sensitivity of current, routinely used analytical methods. The PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing nonroutine methods.
- Organic compounds have not been previously detected at concentrations of concern in site soils.
- All of the exceptions involve target analytes that are not specifically suspected of being present at this site but that are included to assure a broad screening for contaminants of potential concern.
- Actual laboratory quantitation limits may be lower than PRRLs, and analyte concentrations down to MDLs can typically be estimated to allow comparisons to screening levels below PRRLs.

For this project, samples analyzed for metals, VOCs, SVOCs, pesticides, PCBs, and chlorinated herbicides will be reported as estimated values if concentrations are less than PRRLs but greater than MDLs. The MDL for each analyte will be listed in the laboratory's electronic data deliverable (EDD). This procedure is being adopted to help ensure that analytical results can effectively be compared with regulatory criteria for certain compounds where the PRRL is near or below the regulatory criteria. This procedure also will help to ensure that subsequent statistical evaluations of the data will not be biased by high-value, nondetect results.

1.4 PROJECT ORGANIZATION

Table 5 presents the responsibilities and contact information for key personnel involved in soil and groundwater sampling activities for this investigation at AOC 1. In some cases, more than one responsibility has been assigned to one person. Figure 2 presents the organization of the project team.

1.5 SPECIAL TRAINING AND CERTIFICATION

This section outlines the training and certification required to complete the activities described in this SAP. The following sections describe the requirements for TtEMI and subcontractor personnel working on site.

1.5.1 Health and Safety Training

TtEMI personnel who work at hazardous waste project sites are required to meet the Occupational Safety and Health Administration (OSHA) training requirements defined in Title 29 *Code of Federal Regulations* (29 CFR) Part 1910.120(e). These requirements include: (1) 40 hours of formal off-site instruction; (2) a minimum of 3 days of actual on-site field experience under the supervision of a trained and experienced field supervisor; and (3) 8 hours of annual refresher training. Field personnel who directly supervise employees engaged in hazardous waste operations also receive at least 8 additional hours of specialized supervisor training. The supervisor training covers AECRU health and safety program requirements, training requirements, personal protective equipment (PPE) requirements, spill containment program, and health-hazard monitoring procedures and techniques. At least one member of every TtEMI field team will maintain current certification in the American Red Cross "Multimedia First Aid" and "Cardiopulmonary Resuscitation Modular," or equivalent.

TABLE 5
KEY PERSONNEL

Name	Organization	Role	Responsibilities	Contact Information
Mr. Gil Rivera	Navy	Remedial project manager	Responsible for overall project execution and for coordination with base representatives, regulatory agencies, and Navy management Actively participates in DQO process Provides management and technical oversight during data collection	Code: 052GAR Naval Facilities Engineering Command, Engineering Field Activity West Pacific Plaza 2001 Junipero Serra Boulevard, Suite 600 Daly City, CA 94014-1976 (650) 746-7451 RiveraGA@efawest.navfac.navy.mil
Narciso A. Ancog	Navy	QA officer	Responsible for QA issues for all Navy CLEAN work Provides government oversight of TtEMI's QA program Reviews and approves SAP and any significant modifications Has authority to suspend project activities if Navy quality requirements are not met	Naval Facilities Engineering Command, Southwest Division San Diego, CA ancogna@efdswnavfac.navy.mil (619) 532-2540
John Bosche	TtEMI	Installation coordinator	Responsible for ensuring that all TtEMI activities at this installation are carried out in accordance with current Navy requirements and TtEMI CLEAN program guidance	TtEMI 135 Main St., Suite 1800 San Francisco, CA 94105 John.Bosche@ttemi.com (415) 222-8295
Rik Lantz	TtEMI	Project manager	Responsible for implementing all activities called out in the delivery order Prepares or supervises preparation of SAP Monitors and directs field activities to ensure compliance with SAP requirements	TtEMI 200 E. Randolph, Suite 4700 Chicago, IL 60601 Rik.Lantz@TtEMI.com (312) 946-6435
Greg Swanson	TtEMI	Program QA manager	Responsible for regular discussion and resolution of QA issues with Navy QA officer Provides program-level QA guidance to installation coordinator, project manager, and project teams Reviews and approves SAPs Identifies nonconformance through audits and other QA review activities and recommends corrective action	TtEMI 1230 Columbia Street, Suite 1000 San Diego, CA 92101 Greg.Swanson@ttemi.com (619) 718-9676

TABLE 5 (Continued)

KEY PERSONNEL

Name	Organization	Role	Responsibilities	Contact Information
Ron Ohta	TtEMI	Project QA officer	<p>Responsible for providing guidance to project teams that are preparing SAPs</p> <p>Verifies that data collection methods specified in SAP comply with Navy and TtEMI requirements</p> <p>May conduct laboratory evaluations and audits</p>	<p>TtEMI 10670 White Rock Road Ranch Cordova, CA 95670 Ron.Ohta@ttemi.com (916) 853-4506</p>
To be determined	TtEMI	Field team leader	<p>Responsible for directing day-to-day field activities conducted by TtEMI and subcontractor personnel</p> <p>Verifies that field sampling and measurement procedures follow SAP</p> <p>Provides project manager with regular reports on status of field activities</p>	To be determined
To be determined	TtEMI	On-site safety officer	<p>Responsible for implementing health and safety plan and for determining appropriate site control measures and personal protection levels</p> <p>Conducts safety briefings for TtEMI and subcontractor personnel and site visitors</p> <p>Can suspend operations that threaten health and safety</p>	To be determined
Sarah Woolley	TtEMI	Analytical coordinator	<p>Responsible for working with project team to define analytical requirements</p> <p>Assists in selecting a prequalified laboratory to complete required analyses (see Section 2.4 of SAP)</p> <p>Coordinates with laboratory project manager on analytical requirements, delivery schedules, and logistics</p> <p>Reviews laboratory data before they are released to project team</p>	<p>TtEMI 135 Main St., Suite 1800 San Francisco, CA 94105 Sarah.Woolley@ttemi.com (415) 222-8311</p>
Winnie Kwong	TtEMI	Database manager	<p>Responsible for developing, monitoring, and maintaining project database under guidance of project manager</p> <p>Works with analytical coordinator during preparation of SAP to resolve sample identification issues</p>	<p>TtEMI 135 Main St., Suite 1800 San Francisco, CA 94105 Winnie.Kwong@ttemi.com (415) 222-8328</p>

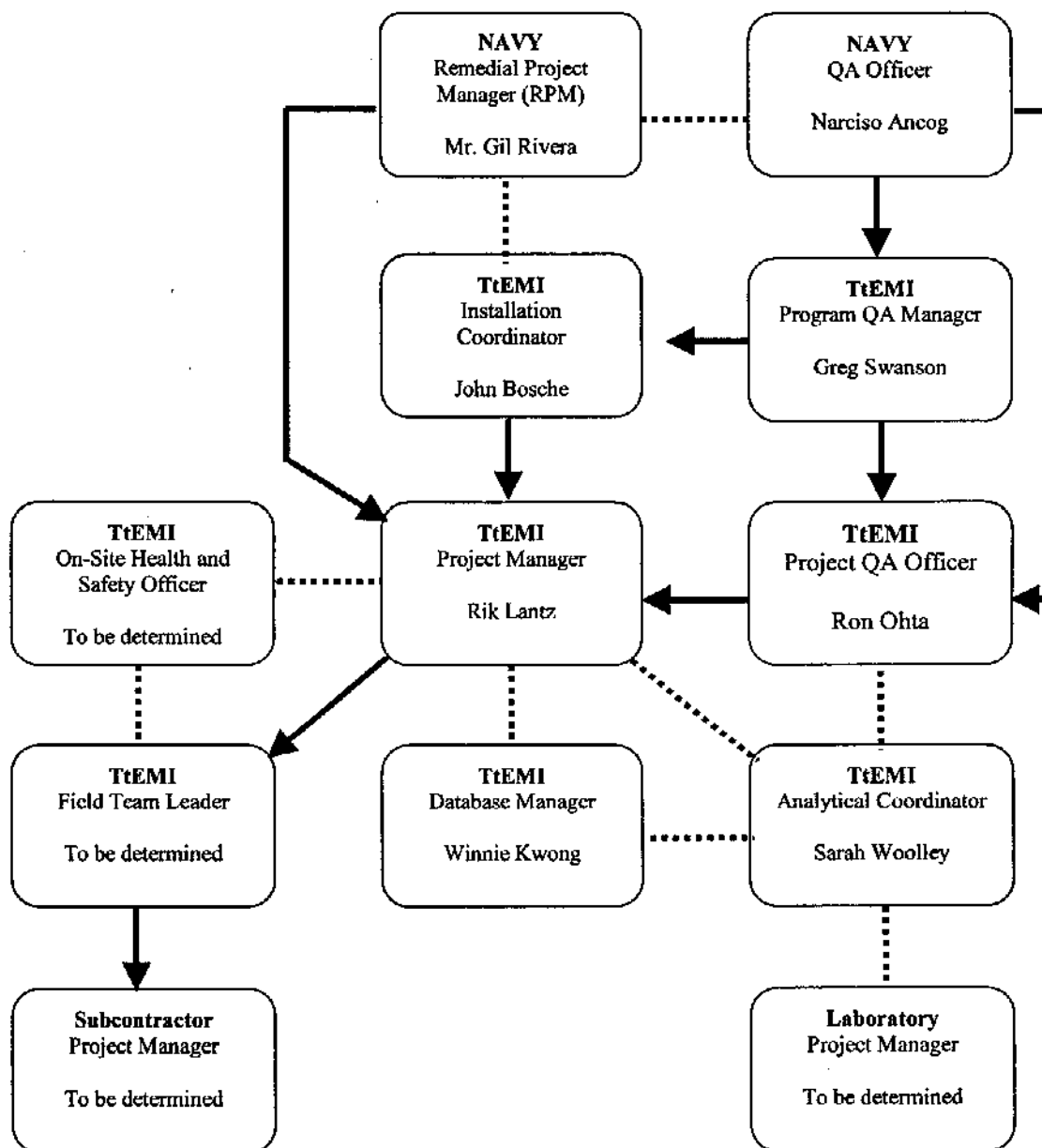
TABLE 5 (Continued)**KEY PERSONNEL**

Name	Organization	Role	Responsibilities	Contact Information
To be determined	Laboratory	Project manager	Responsible for delivering analytical services that meet requirements of SAP Reviews SAP to understand analytical requirements Works with TtEMI analytical coordinator to confirm sample delivery schedules Reviews laboratory data package before it is delivered to TtEMI	To be determined
To be determined	Subcontractor	Project manager	Responsible for ensuring that subcontractor activities are conducted in accordance with requirements of SAP Coordinates subcontractor activities with TtEMI project manager or field team leader	To be determined

Notes

DQO = Data quality objectives
QA = Quality assurance
SAP = Sampling and analysis plan

FIGURE 2
PROJECT TEAM ORGANIZATION CHART



Lines of Authority
Lines of Communication



Copies of TtEMI's health and safety training records, including course completion certification forms for the initial and refresher health and safety training, specialized supervisor training, and first aid and cardiopulmonary resuscitation training, are maintained in project files.

Before work begins at a specific hazardous waste project site, TtEMI personnel are required to undergo site-specific training that thoroughly covers the following areas:

- Names of personnel and alternates responsible for health and safety at a hazardous waste project site
- Health and safety hazards present on site
- Selection of the appropriate personal protection levels
- Correct use of PPE
- Work practices to minimize risks from hazards
- Safe use of engineering controls and equipment on site
- Medical surveillance requirements, including recognition of symptoms and signs that might indicate overexposure to hazardous substances
- Contents of the base-wide health and safety plan (HASP) (TtEMI 1997)

1.5.2 Subcontractor Training

Subcontractors who work on site will certify that their employees have been trained for work on hazardous waste project sites. Training will meet OSHA requirements defined in Title 29 CFR 1910.120(e). Before work begins at the project site, subcontractors will submit copies of the training certification for each employee to TtEMI.

All employees of associate and professional services firms and technical services subcontractors will attend a safety briefing and complete the safety meeting sign-off sheet before they conduct on-site work. This briefing covers the topics described in Section 1.5.1 and is conducted by the TtEMI on-site health and safety officer or other qualified person.

Subcontractors are responsible for conducting their own safety briefings. TtEMI personnel may audit these briefings.

1.5.3 Specialized Training and Certification Requirements

No specialized training and certifications are required for this investigation.

1.6 DOCUMENTS AND RECORDS

Documentation is critical for evaluating the success of any environmental data collection activity. The following sections discuss the requirements for documenting field activities and for preparing laboratory data packages. This section also describes reports that will be generated as a result of this project.

1.6.1 Field Documentation

Complete and accurate documentation is essential to demonstrate that field measurement and sampling procedures are carried out as described in the SAP. Field personnel will use permanently bound field logbooks with sequentially numbered pages to record and document field activities. The logbook will list the contract name and number, the CTO number, the site name, and the names of subcontractors, the service client, and the project manager. At a minimum, the following information will be recorded in the field logbook:

- Name and affiliation of all on-site personnel or visitors
- Weather conditions during the field activity
- Summary of daily activities and significant events
- Notes of conversations with coordinating officials
- References to other field logbooks or forms that contain specific information
- Discussions of problems encountered and their resolution
- Discussions of deviations from the SAP or other governing documents
- Description of all photographs taken

The field team will also use the various field forms (boring logs and well sample sheets) included in Appendix C to record field activities.

1.6.2 Preliminary Data Package

The subcontracted laboratory will prepare a preliminary data package that will consist of the sample identification numbers (ID) and corresponding analytical results. The subcontracting laboratory will

provide TtEMI with a faxed copy of the preliminary summary data package within 7 days after it receives the last sample in the sample delivery group (SDG).

1.6.3 Full Data Package

When a full data package is required, the laboratory will prepare data packages in accordance with the instructions provided in the EPA Contract Laboratory Program (CLP) statements of work (SOW) (EPA 1999a, 2000a). Full data packages will contain all of the information from the summary data package and all associated raw data. Full data package requirements are outlined in Table 6. Full data packages are due to TtEMI within 35 days after the last sample in the SDG is received. Unless otherwise requested, the subcontractor will deliver one copy of the full data package.

TABLE 6
REQUIREMENTS FOR FULL DATA PACKAGES

Organic Analysis		Inorganic Analysis	
Section I	Case Narrative	Section I	Case Narrative
1.	Case narrative	1.	Case narrative
2.	Copies of nonconformance and corrective action forms	2.	Copies of nonconformance and corrective action forms
3.	Chain-of-custody forms	3.	Chain-of-custody forms
4.	Copies of sample receipt notices	4.	Copies of sample receipt notices
5.	Internal tracking documents, as applicable	5.	Internal tracking documents, as applicable
Section II Sample Results - Form I for the following:		Section II Sample Results - Form I for the following:	
1.	Environmental samples, including dilutions and re-analysis	1.	Environmental sample including dilutions and re-analysis
2.	Tentatively identified compounds (TIC) (VOC and SVOC only)	Section III QA/QC Summaries - Forms II through XIV for the following:	
Section III QA/QC Summaries - Forms II through XI for the following:		1.	Initial and continuing calibration verifications (Form II)
1.	System monitoring compound and surrogate recoveries (Form II)	2.	PRRL standard (Form II)
2.	MS and MSD recoveries and RPDs (Forms I and III)	3.	Detection limit standard (Form II-Z)
3.	Blank spike or LCS recoveries (Forms I and III-Z)	4.	Method blanks, continuing calibration blanks, and preparation blanks (Form III)
4.	Method blanks (Forms I and IV)	5.	Inductively coupled plasma (ICP) interference-check samples (Form IV)
5.	Performance check (Form V)	6.	MS and post-digestion spikes (Forms V and V-Z)
6.	Initial calibrations with retention time information (Form VI)	7.	Sample duplicates (Form VI)
7.	Continuing calibrations with retention time information (Form VII)	8.	LCSs (Form VII)
8.	Quantitation limit standard (Form VII-Z)	9.	Method of standard additions (Form VIII)
9.	Internal standard areas and retention times (Form VIII)	10.	ICP serial dilution (Form IX)
10.	Analytical sequence (Forms VIII-D and VIII-Z)	11.	IDL (Form X)
11.	Gel permeation chromatography (GPC) calibration (Form IX)	12.	ICP interelement correction factors (Form XI)
12.	Single component analyte identification (Form X)	13.	ICP linear working range (Form XII)
13.	Multicomponent analyte identification (Form X-Z)		
14.	Matrix-specific method detection limit (MDL) (Form XI-Z)		

TABLE 6 (Continued)

REQUIREMENTS FOR FULL DATA PACKAGES

Organic Analysis		Inorganic Analysis
Section IV	Sample Raw Data - indicated form, plus all raw data	Section IV Instrument Raw Data - Sequential measurement readout records for ICP, graphite furnace atomic absorption (GFAA), flame atomic absorption (AA), cold vapor mercury, cyanide, and other inorganic analyses, which will contain the following information:
1.	Analytical results, including dilutions and re-analysis (Forms I and X)	1. Environmental samples, including dilutions and re-analysis
2.	Tentatively identified compounds (TICs) (Form I—VOA and SVOA only)	2. Initial calibration
		3. Initial and continuing calibration verifications
Section V	QC Raw Data - indicated form, plus all raw data	4. Detection limit standards
1.	Method blanks (Form I)	5. Method blanks, continuing calibration blanks, and preparation blanks
2.	MS and MSD samples (Form I)	6. ICP interference check samples
3.	Blank spikes or LCSs (Form I)	7. MS and post-digestion spikes
		8. Sample duplicates
Section VI	Standard Raw Data - indicated form, plus all raw data	9. LCSs
1.	Performance check (Form V)	10. Method of standard additions
2.	Initial calibrations, with retention-time information (Form VI)	11. ICP serial dilution
3.	Continuing calibrations, with retention-time information (Form VII)	
4.	Quantitation-limit standard (Form VII-Z)	Section V Other Raw Data
5.	GPC calibration (Form IX)	1. Percent moisture for soil samples
		2. Sample digestion, distillation, and preparation logs, as necessary
Section VII	Other Raw Data	3. Instrument analysis log for each instrument used
1.	Percent moisture for soil samples	4. Standard preparation logs, including initial and final concentrations for each standard used
2.	Sample extraction and cleanup logs	5. Formula and a sample calculation for the initial calibration
3.	Instrument analysis log for each instrument used (Form VIII-Z)	6. Formula and a sample calculation for soil sample results
4.	Standard preparation logs, including initial and final concentrations for each standard used	
5.	Formula and a sample calculation for the initial calibration	
6.	Formula and a sample calculation for soil sample results	

Notes:

LCS Laboratory control sample
MS Matrix spike
MSD Matrix spike duplicate
PRRL Project required reporting limit
RPD Relative percent difference

1.6.4 Data Package Format

The subcontracted laboratory will provide EDDs for all analytical results. An automated laboratory information management system (LIMS) must be used to produce the EDD. Manual creation of the deliverable (data entry by hand) is unacceptable. The laboratory will verify EDDs internally before they are issued. The EDD will correspond exactly to the hard-copy data. No duplicate data will be submitted. EDDs will be delivered in a format compatible with Navy Environmental Data Transfer Standards (NEDTS). Results that should be included in all EDDs are as follows:

- Target analyte results for each sample and associated analytical methods requested on the chain-of-custody form
- Method and instrument blanks and preparation and calibration blank results reported for the SDG
- Percent recoveries for the spike compounds in the MS, MSDs, blank spikes, or LCSs
- Matrix duplicate results reported for the SDG
- All reanalysis, reextractions, or dilutions reported for the SDG, including those associated with samples and the specified laboratory QC samples

Electronic and hard copy data must be retained for a minimum of 3 and 10 years, respectively, after final data have been submitted. The subcontractor will use an electronic storage device capable of recording data for long-term, off-line storage. Raw data will be retained on an electronic data archival system.

1.6.5 Reports Generated

A project summary report documenting the TCRA and supplemental sampling activities will be prepared at the conclusion of the field work. The report will include a summary of the TCRA and supplemental sampling activities, objectives of the removal action, chronology of the removal action, analytical results for soil and groundwater samples, analytical results for confirmatory samples, associated QC data, conclusions, and recommendations for the site.

2.0 DATA GENERATION AND ACQUISITION

This section describes the requirements for the following:

- Sampling Process Design (Section 2.1)
- Sampling Methods (Section 2.2.)
- Sample Handling and Custody (Section 2.3)
- Analytical Methods (Section 2.4)
- Quality Control (Section 2.5)
- Equipment Testing, Inspection, and Maintenance (Section 2.6)
- Instrument Calibration and Frequency (Section 2.7)
- Inspection and Acceptance of Supplies and Consumables (Section 2.8)
- Nondirect Measurements (Section 2.9)
- Data Management (Section 2.10)

2.1 SAMPLING PROCESS DESIGN

The soil and groundwater samples collected from the investigation will provide data necessary to evaluate whether further action is warranted at the site after the TCRA and supplemental sampling activities are complete. The following subsections identify the proposed sampling locations and planned chemical analyses for the TCRA, supplemental sampling, and optional sampling activities. Section 2.1 also includes information on surveying sampling locations and locating underground utilities.

2.1.1 Time-Critical Removal Action Sampling Activities

This section describes delineation of hot spots and confirmation sampling

2.1.1.1 Delineation of Hot Spots

For the TCRA, the Navy will establish two 5 by 5 grids of 25-foot by 25-foot grid squares centered at sampling locations GB27 and SB08 (the two hot spots). The central square containing sampling locations GB27 and SB08 will be excavated and removed without further characterization. Composite soil samples will be collected from grid squares contiguous with the central square (first tier grid squares), and the need for excavation and food chain modeling will be used to assess the need for removal of these contiguous grid squares. Because the removal action is being conducted to assess ecological risks and because ecological receptors do not derive their food from a single point, composite samples are

considered appropriate to characterize the limits of hot spots to address ecological risk. To avoid loss of VOCs during compositing, each discrete soil sample that makes up the composite sample will be scanned with a photoionization detector (PID) as soon as the acetate sample sleeve is cut away to assess the presence of VOCs. If the PID indicates that VOCs are present in any discrete sample, the interval showing the highest VOC concentrations on the PID will be sampled for VOCs. Lacking any evidence of the presence of VOCs, the field sampler will collect a single discrete sample for VOC analysis from the soil interval most likely to be contaminated based on discoloration or other visual or olfactory cues.

Soils in the contiguous squares will be characterized by collecting one composite sample from each square. Each grid square will be divided into four equal areas (12.5-foot by 12.5-foot subsquares), and a 3-foot boring will be advanced in the center of each subsquare. Equal volumes of soil will be collected from visibly contaminated waste materials in each of the borings and mixed thoroughly to create a composite sample that represents the entire 25-foot by 25-foot grid square. If no waste material or other contamination is visually apparent, composite soil samples will be collected from the 0- to 0.5-foot depth interval of the soil boring. These soil samples will be analyzed for metals.

A new 95th percentile upper confidence limit on the arithmetic mean (UCL_{95}) that represents remaining soils at AOC 1 will be calculated by adding the new hot spot delineation data to the existing data set and subtracting data from the areas to be excavated. The UCL_{95} that represents remaining soils at AOC 1 will be input into the existing focused food chain model presented in the PA addendum (TtEMI 2001) to evaluate ecological risk for the soils remaining after excavation. If the HQ for any metal exceeds 1.0 as calculated using the more focused food chain model presented in the PA addendum, the grid square with the highest concentration of that metal will be slated for excavation and removal. The HQ will be recalculated in the same manner, using the same data set modified by subtracting the results from the grid spot to be removed.

Grid squares contiguous with any first-tier square slated for removal (second-tier grid squares) will be sampled in the same manner as described previously, and the data set will again be modified by adding new data from the second tier grid squares and subtracting data that represent grid squares to be removed. If the HQ for any metal in exceeds 1.0 as calculated using the more focused food chain model presented in the PA addendum, the grid square will be slated for excavation and removal.

To expedite the hot spot delineation, the laboratory will supply preliminary analytical results for first-tier sampling within 7 days of sample receipt. The Navy will then confirm decisions made regarding second-tier sampling when the validated laboratory data is available.

All first-tier grid squares (eight composite samples around each hot spot) and up to 12 second-tier samples, if necessary, will be collected to further delineate hot spots at the site. Because of budgetary constraints, sampling and excavation beyond the second-tier grid squares will not be conducted under the TCRA. If necessary, characterization and potential excavation of soils contiguous with second-tier grid squares that require excavation will be evaluated separately. Locations of the soil samples, sample IDs, sample depth, and the rationale for selecting these surface soil sampling locations are presented in Table 7. The proposed sampling locations and geographic coordinates of the hot spot sampling locations are shown on Figure 3.

TABLE 7

PROPOSED SAMPLES, RATIONALE, AND ANALYSES

Point Identification	Analyses	Sample ID	Sample Depth (feet bgs)	Rationale
Hot Spot Delineation Sampling				
B7	Pb, Se, Hg	001AOC1SS001	0 to 0.5	Four-point composite sample is considered adequate to characterize a 25-foot by 25-foot grid square.
B8	Pb, Se, Hg	001AOC1SS002	0 to 0.5	Same as above.
B9	Pb, Se, Hg	001AOC1SS003	0 to 0.5	Same as above.
C9	Pb, Se, Hg	001AOC1SS004	0 to 0.5	Same as above.
D9	Pb, Se, Hg	001AOC1SS005	0 to 0.5	Same as above.
D8	Pb, Se, Hg	001AOC1SS006	0 to 0.5	Same as above.
D7	Pb, Se, Hg	001AOC1SS007	0 to 0.5	Same as above.
C7	Pb, Se, Hg	001AOC1SS008	0 to 0.5	Same as above.
TBD (GB 27 Hot Spot, second tier)	Pb, Se, Hg	001AOC1SS009	0 to 0.5	Same as above.
TBD (GB 27 Hot Spot, second tier)	Pb, Se, Hg	001AOC1SS010	0 to 0.5	Same as above.
TBD (GB 27 Hot Spot, second tier)	Pb, Se, Hg	001AOC1SS011	0 to 0.5	Same as above.
TBD (GB 27 Hot Spot, second tier)	Pb, Se, Hg	001AOC1SS012	0 to 0.5	Same as above.
TBD (GB 27 Hot Spot, second tier)	Pb, Se, Hg	001AOC1SS013	0 to 0.5	Same as above.
TBD (GB 27 Hot Spot, second tier)	Pb, Se, Hg	001AOC1SS014	0 to 0.5	Same as above.
I11	Pb, Se, Hg	001AOC1SS015	0 to 0.5	Same as above.
I12	Pb, Se, Hg	001AOC1SS016	0 to 0.5	Same as above.
I13	Pb, Se, Hg	001AOC1SS017	0 to 0.5	Same as above.
J13	Pb, Se, Hg	001AOC1SS018	0 to 0.5	Same as above.
K13	Pb, Se, Hg	001AOC1SS019	0 to 0.5	Same as above.
K12	Pb, Se, Hg	001AOC1SS020	0 to 0.5	Same as above.
K11	Pb, Se, Hg	001AOC1SS021	0 to 0.5	Same as above.
J11	Pb, Se, Hg	001AOC1SS022	0 to 0.5	Same as above.

TABLE 7 (Continued)

PROPOSED SAMPLES, RATIONALE, AND ANALYSES

Point Identification	Analyses	Sample ID	Sample Depth (feet bgs)	Rationale
TBD (Hot Spot SB08, second tier)	Pb, Se, Hg	001AOCISS022	0 to 0.5	Same as above.
TBD (Hot Spot SB08, second tier)	Pb, Se, Hg	001AOCISS024	0 to 0.5	Same as above.
TBD (Hot Spot SB08, second tier)	Pb, Se, Hg	001AOCISS025	0 to 0.5	Same as above.
TBD (Hot Spot SB08, second tier)	Pb, Se, Hg	001AOCISS026	0 to 0.5	Same as above.
TBD (Hot Spot SB08, second tier)	Pb, Se, Hg	001AOCISS027	0 to 0.5	Same as above.
TBD (Hot Spot SB08, second tier)	Pb, Se, Hg	001AOCISS028	0 to 0.5	Same as above.
Hot Spot Confirmation Sampling (Base of GB27 hot spot excavation)				
HSNB1	Pb, Se, Hg	001AOCISB029	2 to 2.5	One sample from base of each excavation or for every 1,500 square feet is considered adequate to verify that TCRA has successfully addressed ecological risk.
HSNB2	Pb, Se, Hg	001AOCISB030	2 to 2.5	Same as above.
Hot Spot Confirmation Sampling (Perimeter of GB27 hot spot excavation)				
HSNP1	Pb, Se, Hg	001AOCISB031	1	One sample from every 100 feet along perimeter of excavation is considered adequate to verify that TCRA has successfully addressed ecological risk.
HSNP2	Pb, Se, Hg	001AOCISB032	1	Same as above.
HSNP3	Pb, Se, Hg	001AOCISB033	1	Same as above.
HSNP4	Pb, Se, Hg	001AOCISB034	1	Same as above.
HSNP5	Pb, Se, Hg	001AOCISB035	1	Same as above.
HSNP6	Pb, Se, Hg	001AOCISB036	1	Same as above.
HSNP7	Pb, Se, Hg	001AOCISB037	1	Same as above.
HSNP8	Pb, Se, Hg	001AOCISB038	1	Same as above.
Hot Spot Confirmation Sampling (Base of SB08 hot spot excavation)				
HSSB1	Pb, Se, Hg	001AOCISB039	2 to 2.5	One samples for every 1,500 square feet was considered adequate to identify any analytes in the soils, if present.
HSSB2	Pb, Se, Hg	001AOCISB040	2 to 2.5	Same as above

TABLE 7 (Continued)

PROPOSED SAMPLES, RATIONALE, AND ANALYSES

Point Identification	Analyses	Sample ID	Sample Depth (feet bgs)	Rationale
Hot Spot Confirmation Sampling (Perimeter of SB08 hot spot excavation)				
HSSP1	Pb, Se, Hg	001AOCISB041	1	One sample from every 100 feet along perimeter of excavation is considered adequate to verify that TCRA has successfully addressed ecological risk.
HSSP2	Pb, Se, Hg	001AOCISB042	1	Same as above.
HSSP3	Pb, Se, Hg	001AOCISB043	1	Same as above.
HSSP4	Pb, Se, Hg	001AOCISB044	1	Same as above.
HSSP5	Pb, Se, Hg	001AOCISB045	1	Same as above.
HSSP6	Pb, Se, Hg	001AOCISB046	1	Same as above.
HSSP7	Pb, Se, Hg	001AOCISB047	1	Same as above.
HSSP8	Pb, Se, Hg	001AOCISB048	1	Same as above.
Cinder Excavation Area (Base)				
CEB1	Pb, Se, Hg	001AOCISB049	2 to 2.5	One sample from every 1,500 square feet at base of excavation is considered adequate to verify that TCRA has successfully addressed ecological risk.
CEB2	Pb, Se, Hg	001AOCISB050	2 to 2.5	Same as above.
CEB3	Pb, Se, Hg	001AOCISB051	2 to 2.5	Same as above.
CEB4	Pb, Se, Hg	001AOCISB052	2 to 2.5	Same as above.
CEB5	Pb, Se, Hg	001AOCISB053	2 to 2.5	Same as above.
CEB6	Pb, Se, Hg	001AOCISB054	2 to 2.5	Same as above.
CEB7	Pb, Se, Hg	001AOCISB055	2 to 2.5	Same as above.
CEB8	Pb, Se, Hg	001AOCISB056	2 to 2.5	Same as above.
CEB9	Pb, Se, Hg	001AOCISB057	2 to 2.5	Same as above.
CEB10	Pb, Se, Hg	001AOCISB058	2 to 2.5	Same as above.
CEB11	Pb, Se, Hg	001AOCISB059	2 to 2.5	Same as above.
CEB12	Pb, Se, Hg	001AOCISB060	2 to 2.5	Same as above.
CEB13	Pb, Se, Hg	001AOCISB061	2 to 2.5	Same as above.
CEB14	Pb, Se, Hg	001AOCISB062	2 to 2.5	Same as above.
CEB15	Pb, Se, Hg	001AOCISB063	2 to 2.5	Same as above.
CEB16	Pb, Se, Hg	001AOCISB064	2 to 2.5	Same as above.
CEB17	Pb, Se, Hg	001AOCISB065	2 to 2.5	Same as above.
CEB18	Pb, Se, Hg	001AOCISB066	2 to 2.5	Same as above.
CEB19	Pb, Se, Hg	001AOCISB067	2 to 2.5	Same as above.
CEB20	Pb, Se, Hg	001AOCISB068	2 to 2.5	Same as above.
CEB21	Pb, Se, Hg	001AOCISB069	2 to 2.5	Same as above.

TABLE 7 (Continued)

PROPOSED SAMPLES, RATIONALE, AND ANALYSES

Point Identification	Analyses	Sample ID	Sample Depth (feet bgs)	Rationale
Cinder Excavation Area (Perimeter)				
CEP1	Pb, Se, Hg	001AOC1SB070	1	One sample from every 100 feet along perimeter of excavation is considered adequate to verify that TCRA has successfully addressed ecological risk.
CEP2	Pb, Se, Hg	001AOC1SB071	1	Same as above.
CEP3	Pb, Se, Hg	001AOC1SB072	1	Same as above.
CEP4	Pb, Se, Hg	001AOC1SB073	1	Same as above.
CEP5	Pb, Se, Hg	001AOC1SB074	1	Same as above.
CEP6	Pb, Se, Hg	001AOC1SB075	1	Same as above.
CEP7	Pb, Se, Hg	001AOC1SB076	1	Same as above.
CEP8	Pb, Se, Hg	001AOC1SB077	1	Same as above.
CEP9	Pb, Se, Hg	001AOC1SB078	1	Same as above.
CEP10	Pb, Se, Hg	001AOC1SB079	1	Same as above.
CEP11	Pb, Se, Hg	001AOC1SB080	1	Same as above.
Potential Source Area (Laboratory)				
LAB	Metals and Organic Compounds (except VOCs)	001AOC1SS081	Surface	This area was not investigated in the past.
	Metals and Organic Compounds	001AOC1GB082	3	Same as above.
	Metals and Organic Compounds	001AOC1GB083	6	Same as above.
Potential Source Area (East Process Tanks)				
EPT	Metals and Organic Compounds (except VOCs)	001AOC1SS084	Surface	This area was not investigated in the past.
	Metals and Organic Compounds	001AOC1GB085	3	Same as above.
	Metals and Organic Compounds	001AOC1GB086	6	Same as above.

TABLE 7 (Continued)

PROPOSED SAMPLES, RATIONALE, AND ANALYSES

Point Identification	Analyses	Sample ID	Sample Depth (feet bgs)	Rationale
Potential Source Area (West Process Tanks)				
WPT	Metals and Organic Compounds (except VOCs)	001AOC1SS87	Surface	This area was not investigated in the past.
	Metals and Organic Compounds	001AOC1GB88	3	Same as above.
	Metals and Organic Compounds	001AOC1GB89	6	Same as above.
Potential Source Area (Northern Boundary)				
NB	Metals and Organic Compounds (except VOCs)	001AOC1SS90	Surface	This area is being investigated to assess whether surface runoff may have carried contaminated materials off-site.
Potential Source Area (West of Sampling Grid)				
WG1	Metals and Organic Compounds (except VOCs)	001AOC1SS93	Surface	This area was not investigated in the past.
	Metals and Organic Compounds	001AOC1GB94	3	Same as above.
	Metals and Organic Compounds	001AOC1GB95	6	Same as above.
WG2	Metals and Organic Compounds (except VOCs)	001AOC1SS96	Surface	This area was not investigated in the past.
	Metals and Organic Compounds	001AOC1GB97	3	Same as above.
	Metals and Organic Compounds	001AOC1GB98	6	Same as above.
WG3	Metals and Organic Compounds (except VOCs)	001AOC1SS99	Surface	Same as above.
	Metals and Organic Compounds	001AOC1GB100	3	Same as above.
	Metals and Organic Compounds	001AOC1GB101	6	Same as above.

TABLE 7 (Continued)

PROPOSED SAMPLES, RATIONALE, AND ANALYSES

Point Identification	Analyses	Sample ID	Sample Depth (feet bgs)	Rationale
Potential Source Area (Warehouse Area)				
WA	Metals and Organic Compounds (except VOCs)	001AOC SS102	Surface	This area was not investigated in the past.
	Metals and Organic Compounds	001AOC GB103	3	Same as above.
	Metals and Organic Compounds	001AOC GB104	6	Same as above.
	Metals and Organic Compounds			
Potential Source Area (Former Spent Acid Pond – OPTIONAL)				
SAP	Metals, pH, and organic compounds	001AOC GB105	9	Existing sample AOC 9 may not have penetrated bottom of former pond.
	Metals, pH, and organic compounds	001AOC GB106	12	Same as above.
	Metals, pH, and organic compounds	001AOC GB107	15	Same as above.
	Metals and Organic Compounds			
Potential Source Area (Concrete slab – OPTIONAL)				
CS	Metals and Organic Compounds (except VOCs)	001AOC GB108	Surface	This area was not investigated in the past.
Potential Source Area (West of Sampling Grid GB43 – OPTIONAL)				
WG4	Metals and Organic Compounds (except VOCs)	001AOC GB110	9	This area was not investigated in the past.
	Metals and Organic Compounds	001AOC GB111	12	Same as above.
	Metals and Organic Compounds	001AOC GB112	15	Same as above.
	Metals and Organic Compounds			
Groundwater Sampling (Round 1)				
MW1-date	Metals, SVOCs, TSS, TDS, (fluoride, OPTIONAL)	001AOC MW001	20	Groundwater was not investigated in the past. Additional organic chemicals will be analyzed in groundwater if soil results indicate a potential source to groundwater.
MW2-date	Metals, SVOCs, TSS, TDS, (fluoride, OPTIONAL)	001AOC MW002	20	Same as above.

TABLE 7 (Continued)

PROPOSED SAMPLES, RATIONALE, AND ANALYSES

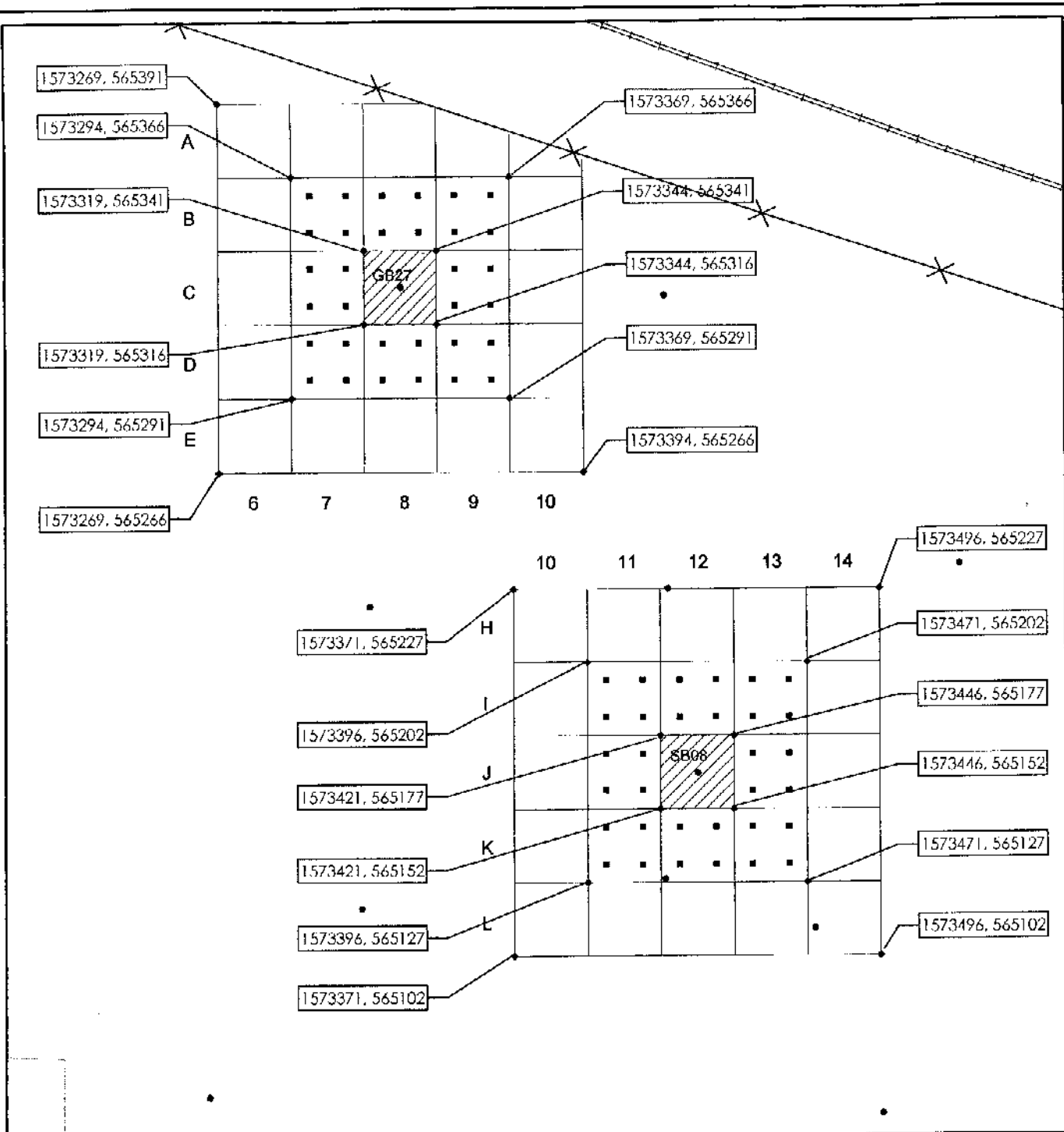
Point Identification	Analyses	Sample ID	Sample Depth (feet bgs)	Rationale
Groundwater Sampling (Round 1)				
MW3-date	Metals, SVOCs, TSS, TDS, (fluoride, OPTIONAL)	001AOC1MW003	20	Same as above.
MW4-date (OPTIONAL)	Metals, SVOCs, TSS, TDS, (fluoride, OPTIONAL)	001AOC1MW004	20	Same as above.
Groundwater Sampling (Round 2)				
MW1-date	Metals, SVOCs, TSS, TDS, (fluoride, OPTIONAL)	001AOC1MW007	20	Groundwater was not investigated in the past. Additional organic chemicals will be analyzed in groundwater if soil results indicate a potential source to groundwater.
MW2-date	Metals, SVOCs, TSS, TDS, (fluoride, OPTIONAL)	001AOC1MW008	20	Same as above.
MW3-date	Metals, SVOCs, TSS, TDS, (fluoride, OPTIONAL)	001AOC1MW009	20	Same as above.
MW4-date (OPTIONAL)	Metals, SVOCs, TSS, TDS, (fluoride, OPTIONAL)	001AOC1MW010	20	Same as above.
IDW (aqueous)				
IDW1	Metals, SVOCs, , pH	001AOC1IDW001	NA	Required for proper disposal.
IDW (soil)				
IDW2	Metals (WET and TCLP), SVOCs, pH	001AOC1IDW002	NA	Required for proper disposal.

Notes:

bgs
Hg
IDW
NA
Pb
Below ground surface
Mercury
Investigation-derived waste
Not applicable
Lead

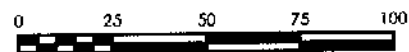
SVOC
Se
TCLP
TCRA
Semivolatile organic compound
Selenium
Toxicity characteristics leachate
procedure
Time-critical removal action

TDS
TSS
VOC
WET
Total Dissolved Solids
Total Suspended Solids
Volatile organic compound
Waste extraction test



LEGEND:

- PREVIOUS SOIL SAMPLING LOCATION
- ◆ GRID POINT;
EASTING AND NORTHING (IN FEET) IN NAD 1927,
CA III COORDINATE SYSTEM SHOWN IN A BOX
- FIRST TIER HOT SPOT DELINEATION
SOIL SAMPLING LOCATION
- 25'x25' GRID CELLS CENTERED AROUND
SAMPLING LOCATIONS AOC1GB27 AND AOC1SB08
- ▨ PROPOSED REMOVAL AREA
- X— FENCE LINE
- +— RAILROAD TRACK



Tt Tetra Tech EM Inc.

NAVAL WEAPONS STATION
SEAL BEACH DETACHMENT
CONCORD, CALIFORNIA

FIGURE 3
HOT SPOT DELINEATION
SOIL SAMPLING LOCATIONS

Although it is unlikely that groundwater will be encountered in the areas to be excavated during the removal action (groundwater is expected to occur at about 20 feet bgs), the Navy will also sample any free-standing groundwater encountered during the excavations. These groundwater samples will be analyzed for metals.

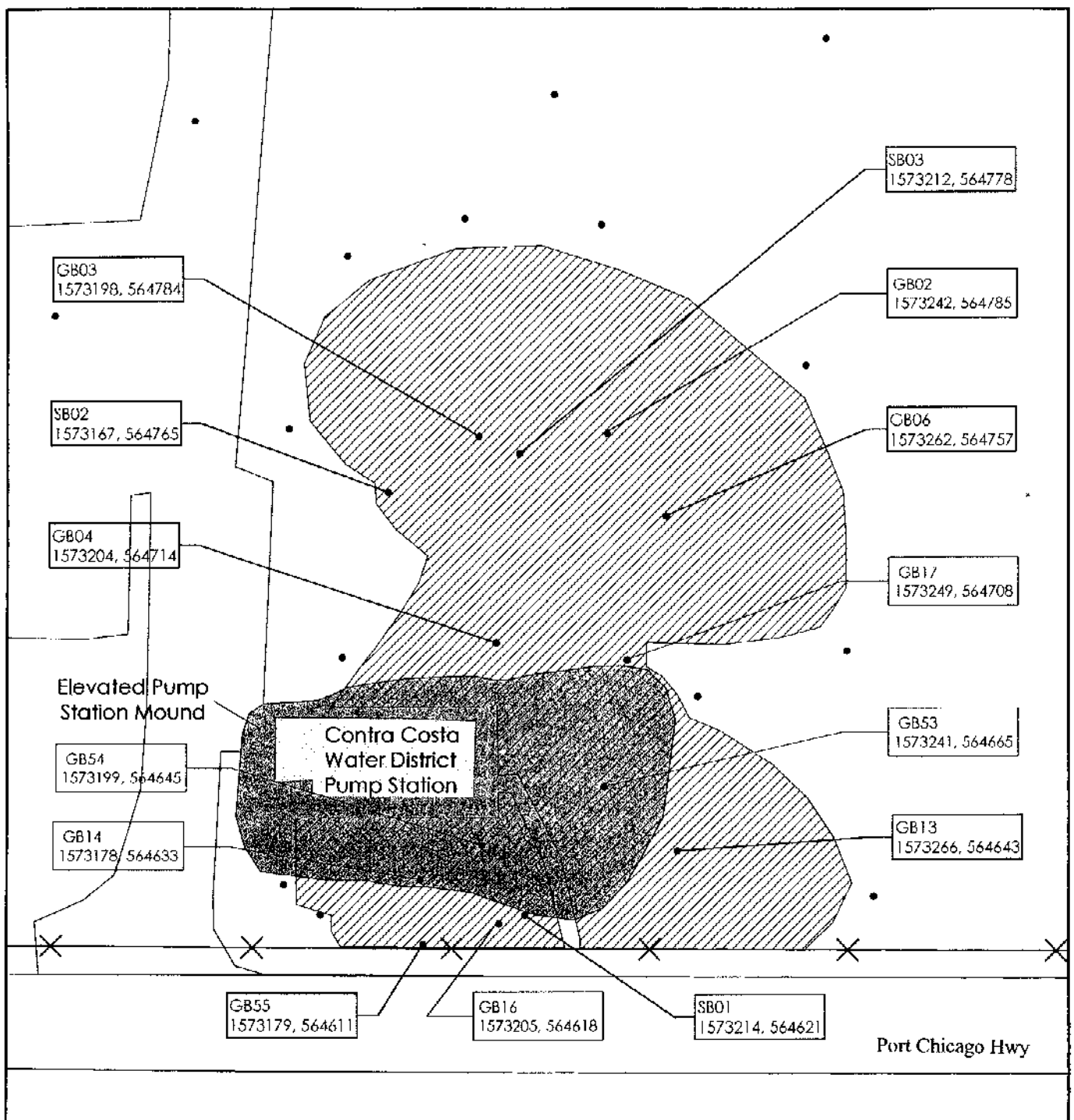
2.1.1.2 Confirmation Sampling

In addition to the ash-like material in the hot spots, the cinder roadbed material will be removed through the TCRA. Discrete confirmation samples will be collected from the sides and the base of the excavations of the cinder roadbed material and at the two hot spots to evaluate the effectiveness of the removal action. Confirmation samples will be analyzed for lead, mercury, and selenium.

For the cinder excavation, discrete confirmation samples will be collected on the sides of the excavation at an approximate frequency of one sample per 100 linear feet. The sidewall confirmation samples will be collected from any interval with visual evidence of contamination or from the midpoint of the sidewall of the excavation if no evidence of contamination is present. Discrete confirmation samples will be collected from the base of the cinder excavation at an approximate frequency of one sample per 1,500 square feet. Confirmation samples will be evenly distributed throughout the base of the excavation. The approximate boundaries of the proposed cinder excavation are shown in Figure 4.

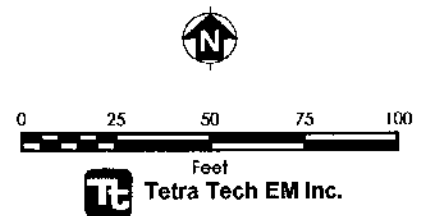
For the hot spot excavations, discrete confirmatory samples will be collected from the sides of the excavation at a frequency of one sample per side wall or one sample per 100 feet, whichever is more frequent. If the criterion of one sample per 100 feet is met, the sample will be collected at the center of the 100-foot interval. The sidewall confirmation samples will be collected from any interval with visual evidence of contamination or from the midpoint of the sidewall of the excavation if no evidence of contamination is present. Confirmatory samples will be collected from the base of the hot spot excavation. If the excavation exceeds 1,500 square feet, samples will be collected an approximate frequency of one sample per 1,500 square feet and equally distributed across the base of the excavation.

All confirmatory samples will be collected from the initial 6 inches of soil on the side or base of the excavations. Confirmation samples will be analyzed for lead, mercury, and selenium.



LEGEND:

- PREVIOUS SAMPLING LOCATION
POINT ID, EASTING AND NORTHING (IN FEET)
IN NAD 1927, CA III COORDINATE SYSTEM
SHOWN IN A BLUE BOX
- PROPOSED CINDER EXCAVATION AREA
- FENCE LINE



NAVAL WEAPONS STATION
SEAL BEACH DETACHMENT
CONCORD, CALIFORNIA

FIGURE 4
PROPOSED CINDER EXCAVATION
AREA LOCATION

If confirmation soil samples contain concentrations of lead, mercury, or selenium that pose an unacceptable ecological risk or exceed industrial PRGs for lead (EPA 2000a), the need for additional site characterization or removal actions will be addressed separately. To determine whether the confirmation samples contain concentrations that pose an unacceptable risk, the Navy will calculate a new UCL_{95} and HQ using the analytical results from the confirmatory samples collected from the sidewalls of the excavation. Samples collected from the base of the excavations (greater than 2 feet bgs) will not be used in the evaluation because ecological receptors are not exposed to soils deeper than 2 feet bgs.

The locations for the confirmatory samples, sample IDs, sample depth, and the rationale for selecting these surface soil sampling locations are presented in Table 7.

2.1.2 Supplemental Sampling Activities

This section discusses supplemental sampling of other potential source areas and groundwater.

2.1.2.1 Other Potential Source Areas

Samples of soil and waste (if present) will be collected from possible source areas to evaluate whether the areas pose an unacceptable risk to human health and ecological receptors. Potential source areas and the type of samples that will be collected are as follows:

- Former laboratory – composite samples at three depths from three soil borings
- Former warehouse area – composite samples at three depths from four soil borings
- Former process tanks east and west of central road – composite samples at three depths from four soil borings
- Northern boundary of site (centered on water tank) – composite surface sample from four locations
- 100 feet west of PA sampling locations GB28, GB35, and GB 36 – discrete samples at three depths from three borings

Soil borings will be advanced from 0 to 6 feet bgs. Soil samples will be collected from three depth intervals of the soil borings: waste material or visible contamination, directly beneath the waste material, and 2 feet beneath the bottom of the waste or visible contamination. If no waste material or visible contamination is apparent in the soil borings, soil samples will be collected from depths of 0 to 0.5 foot

bgs, 3 to 3.5 feet bgs, and 5.5 to 6 feet bgs. Because the composite sample from the northern boundary of the site will be collected to assess potential that surface runoff carried contaminated materials from the site, the sample will be collected from the 0 to 0.5-foot interval only.

For composite samples, equal volumes of soil from the same depth interval in each boring will be mixed thoroughly and sampled. For each sample, at least 6 vertical-inches of soil or waste will be collected at each of the three depth intervals to satisfy the analytical volume requirements. Samples from the three depth intervals will be analyzed for SVOCs, pesticides, PCBs, and chlorinated herbicides, and metals. In addition, samples collected from the depth intervals more than 1 foot below the surface will be analyzed for VOCs. Samples for VOC analysis will not be composited. Instead, VOC samples will be collected using the sampling technique described in Section 1.2.2.3.

The proposed locations of the soil borings, sample IDs, sample depth, and the rationale for selecting these soil sampling locations are presented in Table 7. The proposed sampling locations and their geographic coordinates are presented in Figure 5.

The proposed soil boring locations were selected based on a review of historic aerial photographs and topographic maps that identify where the potential source areas were previously located and the direction of surface water runoff. If more appropriate (visibly contaminated soil or waste) locations are identified in the field near a potential source area, the soil boring locations may be revised to sample such material.

2.1.2.2 Groundwater Investigation

Three monitoring wells will be installed at locations selected to determine the direction of groundwater flow and to evaluate potential sources of contamination. The well locations will be selected after consultation with the regulatory agencies. Once well locations have been selected, the monitoring wells will be installed with well screens that intersect the water table. Based on available information from adjacent properties, the Navy anticipates that groundwater occurs at about 20 feet bgs at the site. The groundwater sampling procedure is discussed in detail in Section 2.2.1.

Samples for chemical analysis will be submitted to a California state-certified laboratory approved by the Navy. Table 8 summarizes the proposed analytical suite for the environmental, IDW, and QC samples for this project.

2.1.2.3 Optional Sampling

Although additional borings and analyses are not currently approved by the Navy, additional sampling may be conducted, as described in this section. Although this work is not yet approved, the additional tasks and analyses described below are included in this SAP for efficiency, should the Navy elect to pursue optional sampling at AOC 1.

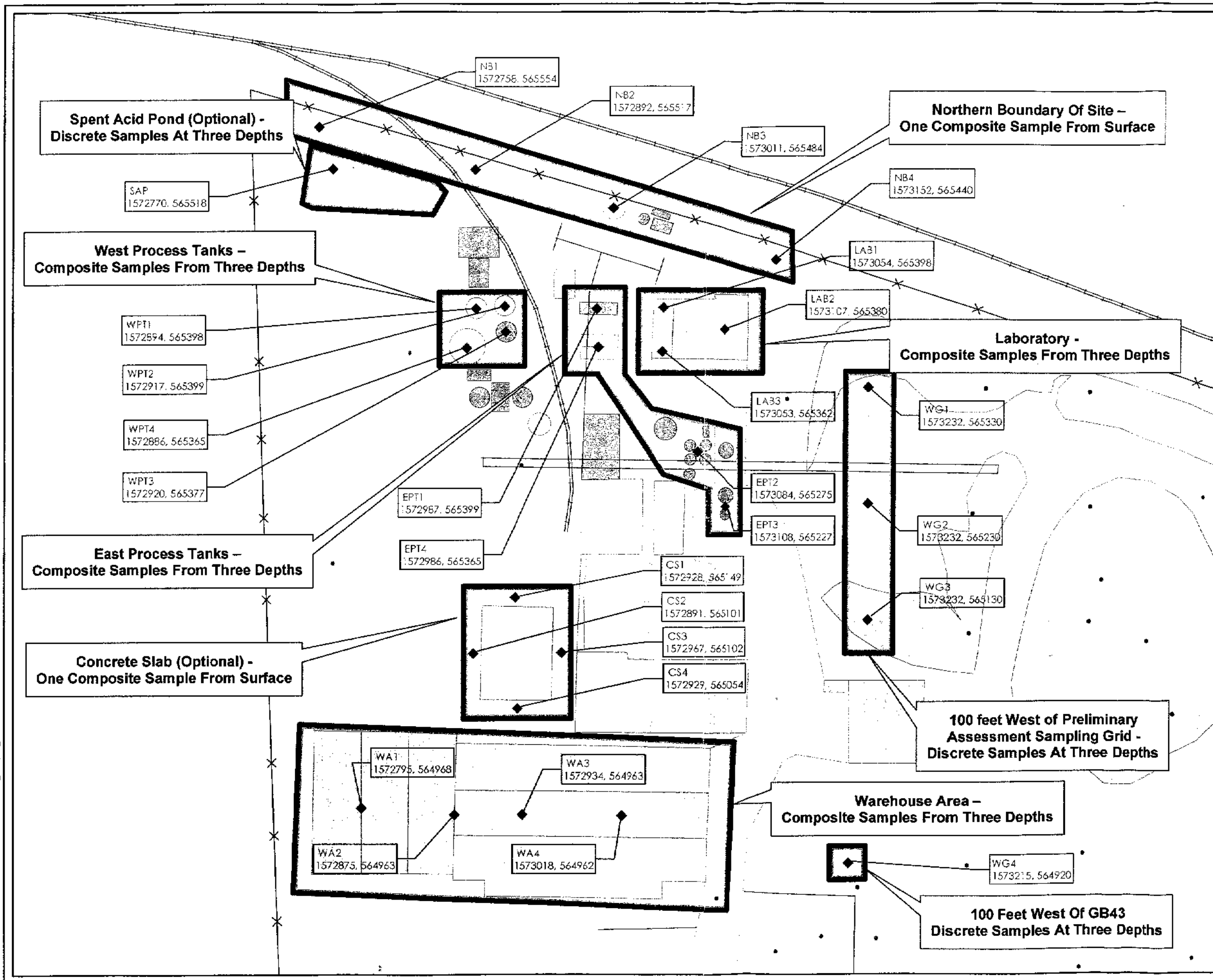
Additional soil boring through spent acid pond: At the December 13, 2001 RPM meeting, regulatory agency personnel expressed concerns about potential contaminant associated with the spent acid pond. Although sample AOC 9 collected at this location from a depth of 4.5 to 5.0 feet below ground surface (bgs) in 1999 did not exhibit elevated concentrations of metals, the regulatory agencies expressed concerns at an April 24, 2002 meeting that the sample may have been collected from a soil interval above the base of the pond. Topographic maps show that the surface elevation in the area is approximately 27 feet. A topographic map of the fertilizer plant shows that the pond had a surface elevation of 24 feet when the factory was active; the elevation of the bottom of the pond is not known. If appropriate, the Navy will advance one boring to 20 feet bgs, collect discrete samples at any soil interval showing evidence of contamination, directly beneath the interval, and 2 feet beneath the base of the interval, and will analyze the samples for metals and pH. Lacking evidence of contamination, the Navy will collect samples from 9 to 9.5 ft, 12 to 12.5 ft, and 15 to 15.5 ft bgs.

Sampling around former concrete slab: At an April 24, 2002 meeting, regulatory agencies expressed concerns that items stored on the concrete slab may have spilled and leaked over the edges of the slab. The Navy will advance 3-foot borings in the soils adjacent to the center of each edge of the former slab at the center of each edge. The Navy will collect discrete samples from any soil interval showing evidence of contamination, create a composite sample by mixing equal portions of discrete samples from each side, and will analyze the composite sample for metals, pesticides, herbicides, SVOCs, and pH. Lacking evidence of contamination, the Navy will collect samples from 0 to 0.5 feet bgs. A discrete sample will be collected for VOC analysis following the sampling procedure described in Section 1.2.2.3.

Boring 100 feet west of sampling grid GB43: In addition to the supplemental samples collected 100 feet west of PA sampling locations GB28, GB35, and GB 36, the Navy will collect, if appropriate, additional discrete samples at a location approximately 100 feet west of GB43 following sample procedures described in Section 1.2.2.3. Samples from this boring will be analyzed for a comprehensive list of chemicals, including VOCs, SVOCs, metals, pesticides, PCBs, and chlorinated herbicides.

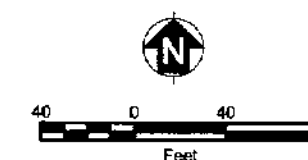
Groundwater Sampling: A fourth monitoring well may be installed to evaluate groundwater contamination at AOC 1. A groundwater sample from this well will be analyzed for metals, SVOCs, TSS, and TDS. If nearby soils indicate that other organic compounds are present at concentrations that may affect groundwater, groundwater samples will be analyzed for those other organic compounds present in nearby soils.

Analyze samples for fluoride: At an April 24, 2002 meeting, regulatory agencies expressed a concern that the phosphoric acid wet process that appears to have been used at the fertilizer plant may be associated with unsafe concentrations of fluoride. If appropriate, the Navy will analyze soil samples and one round of groundwater samples from supplemental sampling activities for fluoride, and compare with regulatory criteria.



LEGEND:

- FEATURES SHOWN ONLY IN 1967 MAP
- FEATURES SHOWN IN 1974 AERIAL PHOTOGRAPH
- EXISTING SAMPLING LOCATION
- ◆ NEW PROPOSED POINT: POINT ID, EASTING AND NORTHING (IN FEET) IN NAD 1927, CA III COORDINATE SYSTEM SHOWN IN A BLUE BOX



Tetra Tech EM Inc.

NAVAL WEAPONS STATION
SEAL BEACH DETACHMENT
CONCORD, CALIFORNIA

FIGURE 5
PROPOSED SAMPLING LOCATIONS
IN POTENTIAL SOURCE AREAS

TABLE 8

SUMMARY OF INVESTIGATION AND INVESTIGATION-DERIVED WASTE ANALYSIS

Analytical Methods	Matrix	Field Samples	Field Duplicates (at 10%)	Equipment Rinsate	Trip Blank	Total No. of Samples	MS/MSD (at 5%) ^a
TCRA Soil Sampling ^b							
Metals (Hg, Se, Pb)	Soil	80	NA	NA	NA	80	4
	Water	NA	NA	1	NA	1	NA
Supplemental Soil Sampling							
VOC	Soil	20	NA	NA	NA	20	1
	Water	NA	NA	1	1	2	NA
SVOC	Soil	30	NA	NA	NA	30	2
	Water	NA	NA	1	NA	1	NA
Pesticides	Soil	30	NA	NA	NA	30	2
	Water	NA	NA	1	NA	1	NA
Chlorinated herbicides	Soil	30	NA	NA	NA	30	2
	Water	NA	NA	1	NA	1	NA
PCBs	Soil	30	NA	NA	NA	30	2
	Water	NA	NA	1	NA	1	NA
Metals	Soil	30	NA	NA	NA	30	NA
	Water	NA	NA	1	NA	1	NA

TABLE 8 (Continued)

SUMMARY OF INVESTIGATION AND INVESTIGATION-DERIVED WASTE ANALYSIS

Analytical Methods	Matrix	Field Samples	Field Duplicates (at 10%)	Equipment Rinsate	Trip Blank	Total No. of Samples	MS/MSD (at 5%) ²
Supplemental Groundwater Sampling							
SVOC	Water	6	1	2	NA	9	1
pH	Water	6	1	2	NA	9	1
Metals	Water	6	1	2	NA	9	NA
Optional Sampling							
VOC	Soil	3	0	0	1	4	1
SVOC	Soil	4	0	0	NA	4	1
Pesticides	Soil	4	0	0	NA	4	1
Chlorinated herbicides	Soil	4	0	0	NA	4	1
PCBs	Soil	4	0	0	NA	4	1
Metals	Soil	4	0	0	NA	4	NA
SVOC	Water	2	0	0	NA	2	1
pH	Water	2	0	0	NA	2	1
Metals	Water	2	0	0	NA	2	NA
IDW Samples							
VOC	Soil	1	NA	NA	NA	1	NA
	Water	1	NA	NA	NA	1	NA
SVOC	Soil	1	NA	NA	NA	1	NA
	Water	1	NA	NA	NA	1	NA
Pesticides	Soil	1	NA	NA	NA	1	NA
	Water	1	NA	NA	NA	1	NA

TABLE 8 (Continued)

SUMMARY OF INVESTIGATION AND INVESTIGATION-DERIVED WASTE ANALYSIS

Analytical Methods	Matrix	Field Samples	Field Duplicates (at 10%)	Equipment Rinsate	Trip Blank	Total No. of Samples	MS/MSD (at 5%) ^a
Chlorinated herbicides	Soil	1	NA	NA	NA	1	NA
	Water	1	NA	NA	NA	1	NA
PCBs	Soil	1	NA	NA	NA	1	NA
	Water	1	NA	NA	NA	1	NA
pH	Soil	1	NA	NA	NA	1	NA
	Water	1	NA	NA	NA	1	NA
Metals	Water	1	NA	NA	NA	1	NA
	Soil	1	NA	NA	NA	1	NA
Metals (WET)	Water	1	NA	NA	NA	1	NA
	Soil	1	NA	NA	NA	1	NA
Metals (TCLP)	Water	NA	NA	NA	NA	1	NA
	Soil	1	NA	NA	NA	1	NA

^a Matrix spike and matrix spike duplicates are not considered additional samples.

^b This table presents a conservative estimate of the number of samples to be collected. It includes: (1) first tier hot spot delineation samples, (2) the maximum number of budgeted second tier hot spot delineation samples, (3) cinder excavation confirmation samples, and (4) hot spot excavation confirmation samples.

^c It is assumed that one composite soil sample and one composite water sample will be sufficient to characterize and dispose of the IDW generated during this investigation.

^d Metals will include waste extraction test for analysis of IDW soils.

PCB Polychlorinated biphenyls
SVOC Semivolatile organic compounds
TCLP Toxicity characteristic leaching procedure
VOC Volatile organic compound
WET Waste extraction test

2.1.3 Rationale for Selecting Analytical Parameters

The rationale for selecting analytical parameters for the TCRA and supplemental sampling activities are described in the following text.

2.1.3.1 Time-Critical Removal Action Sampling Activities

Metals have been detected at the site at relatively high concentrations. A human health and ecological risk assessment conducted as part of the PA found that human health risks at the site from metals are mitigated by limited exposure; however, unacceptable ecological risks are associated with mercury and selenium (TtEMI 2001). Organic contaminants have been detected sporadically at relatively low concentrations, and a human health risk assessment and an ecological risk assessment conducted as part of the PA identified no unacceptable human or ecological risks associated with organic contaminants (TtEMI 1999). TCRA sampling activities will only include analyses for lead, selenium, and mercury.

2.1.3.2 Supplemental Sampling Activities

No samples of groundwater have been collected to evaluate whether site-related chemicals may have migrated to and adversely affected the quality of groundwater at or downgradient from the site. In addition, no soil samples have been collected in the potential source areas. Supplemental soil samples will be analyzed for metals, VOCs, SVOCs, pesticides, PCBs, and chlorinated herbicides to provide a broad coverage of all potential site-related contaminants. Groundwater samples will be analyzed for metals, SVOCs, TSS, and TDS, unless other organic contaminants are detected in nearby soils, in which case groundwater samples will be analyzed for the same compounds detected in soils.

2.1.3.3 Optional Sampling Activities

No soil samples have been collected from the concrete slab area or from a location 100 feet west of GB43, and the soil sample collected from the former spent acid pond area may have been collected from a soil interval above the base of the former pond. Soil samples may be collected from these locations if the Navy determines that such sampling is appropriate. If collected, samples from these areas will be analyzed for metals, VOCs, SVOCs, pesticides, PCBs, and chlorinated herbicides to provide a broad coverage of all potential site-related contaminants. If soil samples are collected within 1 foot of the ground surface, these samples will not be analyzed for VOCs. If collected, samples from the former spent acid pond will be analyzed for metals and pH.

A fourth monitoring well may be installed to evaluate groundwater contamination at AOC 1. A groundwater sample from this well will be analyzed for metals, SVOCs, TSS, and TDS. If nearby soils indicate that other organic compounds are present at concentrations that may affect groundwater, groundwater samples will be analyzed for other organic compounds present in nearby soils.

At an April 24, 2002 meeting, regulatory agencies expressed a concern that the phosphoric acid wet process that appears to have been used at the fertilizer plant may be associated with unsafe concentrations of fluoride. To address this concern, the Navy may elect to add fluoride to the list of analytes for the supplemental sampling activities.

2.1.3.4 Investigation-Derived Waste

The suite of analyses specified for IDW has been selected to meet the waste characterization requirements of disposal facilities.

2.1.4 Surveying

For TCRA, supplemental, and optional sampling activities, the Navy has predetermined the geographic coordinates of soil sampling locations based on a geographically referenced site map. The Navy will identify the sampling locations in the field with a hand-held geographic positioning system (GPS) system using predetermined coordinates. Fixed points on the site that can be used for navigation purposes include the concrete pad and fence around the pump station on the south side of the site as well as the perimeter fence that encloses the site. Should the Navy, in consultation with the regulatory team, need to revise any soil sampling locations based on field observations, the geographic coordinates of the revised

sampling locations will be recorded using the GPS unit. Additionally, confirmation sampling locations will be recorded using the GPS unit.

After the monitoring wells have been installed, a professional land surveyor, licensed by the State of California, will survey the location of each well to a precision of 0.10 foot horizontally and the top of casing elevation of each well to a precision of 0.01 foot vertically. Horizontal coordinates shall be established to the closest 0.1 foot and referenced to the California State Plane Coordinate System, Zone 3. Ground surface and all other vertical elevations shall be surveyed to the closest 0.01 foot. These elevations shall be referenced to the National Geodetic Vertical Datum of 1929. The survey data will be merged with existing survey data in the installation database.

2.1.5 Underground Utilities Survey

An underground utilities survey will be conducted to clear all surface soil, soil boring, and monitoring well locations before any intrusive activities begin. The survey will include water distribution piping, telecommunications lines, storm sewer lines, sanitary sewer lines, industrial wastewater lines, gas lines, fire water lines, fuel product lines, and electrical lines.

2.2 SAMPLING METHODS

This section describes the procedures for sample collection, including sampling methods and equipment, sample preservation requirements, decontamination procedures, and management of IDW.

2.2.1 Sampling Methods and Equipment

Sampling methods and equipment are described in the following text.

2.2.1.1 Soil Sampling for Time-Critical Removal Action, Supplemental Sampling, and Optional Sampling

Soil samples to delineate hot spots and to characterize potential source areas (including optional sampling at the concrete slab and former spent acid pond) will be collected by direct push technology using a Geoprobe rig, a hydraulic drive-point system operated from the rear of a truck. A hydraulic pump mounted directly to the truck's transmission powers the probe unit. Sampling equipment comprises a 4-foot-long stainless steel sampler, lined with acetate and advanced to the desired depth using direct push. The operation of the Geoprobe will follow general practices listed in TrEMI SOP 054, "Using the Geoprobe System" (Appendix B).

For hot spot delineation, the probe will be advanced to 3 feet bgs at 4 locations for each grid square. The acetate sleeves will be removed from the sampler, cut in half longitudinally, and examined. Ash-like material, if present, or soil from the core will be placed in a steel mixing bowl lined with aluminum foil and thoroughly mixed with an aluminum foil-lined utensil to homogenize the material. Aluminum foil lining will be changed between samples.

For potential source areas, the probe will be advanced twice in 4-foot increments to collect soil from 0 to 6 feet bgs. The acetate will be removed from the sampler, cut in half longitudinally, and examined. Waste-like material in the core tubes will be placed in disposable containers, where it will be homogenized. In addition, soil from the surface of the core and from below the waste-like material will be placed in separate disposable containers and homogenized. If no waste-like material is present in the 0- to 6-foot-bgs depth interval, soil samples will be collected from 0 to 0.5 feet bgs, 3 to 3.5 feet bgs, and 5.5 to 6 ft bgs.

For optional sampling at the former spent acid pond, the Navy may elect to advance one boring to 20 feet bgs, collect discrete samples at any soil interval showing evidence of contamination, directly beneath the interval, and 2 feet beneath the base of the interval, and analyze the samples for metals and pH. Lacking evidence of contamination, the Navy will collect samples from 9 to 9.5 ft, 12 to 12.5 ft, and 15 to 15.5 ft bgs. If the Navy determines that sampling at the concrete slab is merited, the Navy will advance 3-foot borings at the center of each edge of the former slab within 1 foot of the edge. The Navy will collect discrete samples from any soil interval showing evidence of contamination or from the surface lacking such evidence, and will combine equal amounts from the four discrete samples to create a single composite sample. Lacking evidence of contamination, samples will be collected from 0 to 0.5 feet.

Soil samples collected from potential source areas for VOC analysis will be containerized with an EnCore™ sampler device, which is approved for this use by EPA. The EnCore™ sampler is a zero-headspace sealed device used to transport solid samples from the field to laboratory, where they are preserved. Samples collected from the split-spoon sampler must be subsampled with the EnCore™ sampler as soon as possible after the core is exposed to ambient conditions. Samples collected using this method must be preserved or analyzed by the laboratory within 48 hours of collection. Three EnCore™ sample aliquots are required for each sample. Discrete samples from the most visibly contaminated soil interval more than 1 foot from the surface will be collected for VOC analysis to reduce the possibility of loss of VOCs.

Confirmatory soil samples will be collected using a trowel. The required volume of soil will be placed in appropriate sample containers for shipment to the laboratory.

Table 7 presents the proposed identification numbers for soil samples, depth of samples, and the rationale for each sampling location.

2.2.1.2 Supplemental Groundwater Sampling

Groundwater monitoring wells will be installed according to procedures specified in TtEMI SOP 20, "Monitoring Well Installation" (Appendix B). A brief description of the procedure for monitoring well installation is outlined in the following text. Monitoring well borings will be installed with 8-1/4-inch steel, hollow stem augers. Split-spoon samples for lithologic logging will be collected continuously from the surface to the total depth of the boring, and a detailed lithologic log of each boring will be prepared during drilling by the field geologist. The wells will be constructed of 4-inch-diameter schedule 40 polyvinyl chloride (PVC). Well screens will be 10-feet long, 4-inch-diameter schedule 40 PVC, 0.010-inch slot-size to allow suitable recharge in low-permeability formations and to allow seasonal water table fluctuations. The well screen will intersect the water table, and the top of the well screen will be set at 2 feet above the water table. The filter pack will consist of coarsely graded sand and be installed by pouring from the surface through the interval from 1 foot above and to 1 foot below the well screen. A filter collar of 1 foot of bentonite pellets will be installed at the top of the filter pack, and the annular space from the top of the filter collar to the surface will be filled with cement-bentonite grout, emplaced with a tremmie pipe from the bottom of the open annular space to the surface. The surface completion will be a concrete pad and stove-pipe outer protective casing. If the well is installed in an area where vehicular traffic is expected, 5-foot bumper posts will be installed to protect the well. The wells will be secured with keyed-alike padlocks for well security.

Low flow-rate purging techniques will be used, where technically feasible, to obtain groundwater samples from wells. Low flow-rate purging will be considered technically infeasible if the water level is more than 25 feet bgs or if the well is unable to support a recharge rate of 0.1 liter per minute as described in the following text. Studies by EPA have shown that low flow rate purging techniques can be used to obtain more accurate and representative groundwater samples for metals analyses than conventional sampling and filtering techniques (Puls and Powell 1992). A principle objective of low flow rate purging is to avoid entraining silt- and clay-sized particles in groundwater samples by purging wells at low velocities. Low flow-rate purging is intended to establish direct flow from the aquifer to the sample container at velocities and flow conditions comparable to *in situ* flow velocities. By using low flow rate purging techniques, the sampling process more closely matches natural groundwater flow conditions and transport of suspended solids, and analytical problems and uncertainties caused by turbidity are reduced. The field procedure for low flow-rate sampling techniques is described as follows:

1. The breathing zone will be monitored with a photoionization detector during removal of each well cap, and the reading will be compared with the background reading for the site to select the appropriate level of personal protection.
2. The depth to water will be measured with an electric-sounder water level meter to determine the equilibrium water level.
3. A weighted Tygon® or polyethylene tube will be gently lowered into the well to a depth of 3.5 feet below the equilibrium water level or 2 feet below the top of the well screen (whichever is greater) and secured to the outer well casing with tape or plastic ties.
4. Well purging will be initiated slowly and increased gradually to a rate of approximately 0.15 liter per minute (L/min) using a peristaltic pump. Purge water stabilization parameters, including pH, temperature, electrical conductivity, dissolved oxygen, and turbidity, will be measured at intervals of a minimum of 1 liter (L) and recorded on well sampling sheets or in field notebooks. Purge water will be discharged into a graduated cylinder, and the volume of water purged will also be measured and recorded on well sampling sheets. If the drawdown of the water level is 0.3 foot or greater at that pumping rate, procedures 5 and 6 will be initiated. If the water level drawdown is less than 0.3 foot at that pumping rate and the water level is stable, the rate will be increased to the maximum rate at which a static water level is obtained (up to 0.25 L/min), and procedures 7 and 8 will be initiated.
5. When drawdown is more than 0.3 foot at a rate of 0.15 L/min, a modified low-flow purge protocol will be attempted. Using the modified low-flow purge protocol, the pump rate will be increased to a maximum of 1 L/min, and the water level will be drawn down to 1.5 to 3 feet from the equilibrium water level.
6. The pumping rate will then be adjusted within the range of 0.1 to 0.25 L/min until the water level in the well is stable and the recharge rate matches the discharge rate. If the water level continues to decrease at a pumping rate of 0.1 L/min, low-flow rate purging will be considered technically unfeasible, and the well will be purged by the alternative technique described in the following text.
7. The purge water will be considered stabilized after the collection of a minimum of eight measurements (8 L purged) and three successive measurements of each of the stabilization parameters that fall within the following ranges:
 - pH: ± 0.1
 - Electrical conductivity: ± 3 percent microSiemens per centimeter
 - Temperature: ± 0.5 °C
 - Dissolved oxygen: ± 0.2 milligram per L
 - Turbidity: ± 15 percent relative percent difference or three successive measurements of less than 15 nephelometric turbidity units
8. Well stabilization parameters will be expected to asymptotically approach a constant value as the purge water begins to stabilize. If well stabilization parameters are within the ranges specified previously, but still appear to be approaching an asymptotic value, well purging will be continued until the purge water appears to be at equilibrium or until a maximum of 20 L has been purged from the well.

In cases where recharge rates in the formation will not allow low flow-rate purging, the wells will be purged dry, allowed to recharge overnight, and sampled the following day, as described in the following list:

1. All water will be purged from the well with disposable Teflon® bailers. A weighted Tygon® or polyethylene tube will then be gently lowered into the well to a depth of 3.5 feet below the equilibrium water level or the middle of the well screen (whichever is greater) and secured to the outer well casing with tape or plastic ties.
2. The well will be allowed to recharge and will be sampled with a peristaltic pump (if possible) after the well has recovered to within 80 percent of the initial water level, but not later than 24 hours after purging.

Well stabilization parameters, including temperature, pH, electrical conductivity, dissolved oxygen, and turbidity, will be measured immediately before sampling and recorded on well sampling sheets or in field notebooks.

The following procedures will be followed in collecting groundwater samples from monitoring wells and piezometers after purging has been completed:

1. Measuring and sampling equipment will be decontaminated before samples are collected from each location.
2. During sampling, well purging equipment will be positioned so that potential sources of VOCs, such as vehicles, gasoline engines, or fuel tanks, are downwind of the location of the well or piezometer.
3. When the low flow-rate purging techniques are used or if samples can be collected with a peristaltic pump, water samples will be collected directly from the discharge of the peristaltic pump. If samples cannot be collected with a peristaltic pump, disposable bailers will be used.
4. Groundwater samples collected for metals analysis using bailers will be filtered in the field. The required volume of water will be collected in a laboratory-cleaned, unpreserved, 1-L plastic bottle. The water from the unpreserved bottle will be filtered into a laboratory-cleaned, nitric-acid-preserved, 1-L plastic bottle using a peristaltic pump with an in-line, disposable, 0.45-micron filter.
5. Groundwater samples collected for metals analysis using the peristaltic pump will not be filtered in the field.
6. The 40-milliliter (mL) vials for analyses for VOCs (three for each analysis) will be filled first. After the bottle has been sealed with a Teflon®-lined cap, the bottle will be inverted and tapped lightly to check for air bubbles. No air-filled headspace is allowed in the bottles. The bottles for analyses for metals, SVOCs, pesticides, and any other inorganic compounds will be filled last.

Electric-sounder water level meters used during groundwater sampling activities will be decontaminated before each use by washing the probe and the portion of the cable directly above the probe with distilled water and wiping those parts clean with a disposable paper towel.

The required volumes of groundwater will be placed in appropriate sample containers for shipment to the laboratory. Purged water will be placed in 55-gallon drums at the IDW area until the water is transported off site for disposal.

Groundwater samples from each monitoring well will be analyzed for metals, SVOCs, TSS, and TDS, and will be analyzed for VOCs, chlorinated herbicides, and pesticides/PCBs only if these contaminants are detected at significant concentrations in soil. To achieve analytical detection limits for mercury that are lower than the applicable regulatory criterion, specialized "ultra-clean" sampling methods will be required. Section 8.0 of EPA Method 1669: Sampling Ambient Water for Determination of Trace Metals at EPA Water Quality Criteria Levels (included with this document as Appendix F) details the required sampling methods, which will be followed closely to collect samples for mercury analysis. In brief, Method 1669 involves using specially cleaned containers and sampling equipment, a two-person sampling team with members designated as "dirty-hands" and "clean-hands," specific functions for each team member, and specific personnel protective equipment requirements. The "clean-hands" sampling team member handles the sample and all operations involving contact with the sample. The "dirty-hands" sampling team member handles all other functions, such as preparing the sampling equipment and operation of machinery.

Table 7 presents the proposed identification numbers for groundwater samples, depth of samples, and the rationale for each sampling location. Two rounds of groundwater sampling are scheduled for this investigation.

2.2.2 Decontamination

Drilling and direct push sampling equipment, including rods, augers, split spoon samplers, and the back end of the rig, will be steam cleaned before work begins and between installation of each soil boring. Decontamination of the equipment will follow general practices listed in TtEMI SOP 002, "General Equipment Decontamination" (Appendix B). A portable steam cleaner and potable water will be used for decontamination, and all water derived from decontamination will be collected and temporarily stored on site for characterization. No other equipment will require decontamination.

2.2.3

Management of Investigation-Derived Waste

IDW will include soil cuttings, purged groundwater, and wastewater from decontamination procedures and collection of equipment rinsate samples. The IDW will be containerized in drums.

Three drums of solid IDW will likely be generated from hot spot delineation and sampling of potential source areas. Twenty drums of solid IDW will be generated from installation of the new monitoring wells. One composite IDW soil sample will be obtained from these drums. The soil sample will be analyzed for VOCs, SVOCs, chlorinated and nonchlorinated pesticides, chlorinated herbicides, pH, ignitability, reactivity, and WET and TCLP metals for characterization before disposal.

One drum of wastewater will be generated from each well during well development, and half drum of waste water will be generated during each sampling event for each well. Water from the first well sampling will be combined with well development waste; therefore, a total of eight drums of wastewater will likely be generated. One composite sample collected from the drum will be sent to the laboratory for the following analyses: VOCs, SVOCs, pesticides, PCBs, chlorinated herbicides, pH, flash point, and metals.

2.2.4

Sample Containers and Holding Times

The type of sample containers to be used for each analysis, the sample volumes required, the preservation requirements, and the maximum holding times for samples before extraction and analysis are presented in Table 9.

2.3

SAMPLE HANDLING AND CUSTODY

The following subsections describe sample handling procedures, including sample identification and labeling, documentation, chain of custody, and shipping.

2.3.1

Sample Identification

A unique sample identification number will be assigned to each sample collected during this project. The sample identification numbering system is designed to be compatible with a computerized data management system that includes previous results for samples collected at this installation. The sample numbering system allows each sample to be uniquely identified and provides a means of tracking the sample from collection through analysis. The numbering system indicates the delivery order number and

site name, sample type, and the location number. For the Geoprobe samples, a number will be added to specify the position of the sample in the vertical sequence. The numbering scheme is illustrated as follows:

Delivery Order Number	001
Site	AOC 1
Sample Type	SS – surface soil sample GB– soil sample collected below surface soil samples by direct push (Geoprobe) technology SB– Confirmation samples MW– groundwater and aqueous QC samples IDW– investigation derived waste
Sequential Sample Number	Specific sampling locations will be numbered consecutively for each specific sampling activity

For example, the composite soil sample collected by Geoprobe under Delivery Order No. 001 at AOC 1 at point location B7 (first location) will be designated 001AOC1GB001.

Field QC samples for this investigation will include equipment rinsates, trip blanks, and duplicates for groundwater samples. One equipment rinsate (ER) per sampling event will be required from the Geoprobe sampling equipment and the hand auger. The ID for this sample will be the consecutive sample ID at the time of collection. One field duplicate will be collected for each groundwater sampling event collected, and the ID for this sample will be the consecutive ID at the time of collection. No field duplicates will be collected for soil samples.

If conditions at the site require that a field blank be collected during sampling, such as strong winds or excavation near the site, the field blank will be analyzed for the same suite of analytes as the equipment rinsates. The sample ID for the field blank will be the consecutive sample ID at the time it is collected. Because the probability that field blanks will be necessary for this investigation is low, this potential QC sample is not included in Table 8.

Additional volume may be required for MS/MSD analysis by the laboratory. No special nomenclature requirements apply to these samples.

2.3.2 Sample Labels

A sample label will be affixed to all sample containers. The label will be completed with the following information written in indelible ink:

- Project name and location
- Sample identification number
- Date and time of sample collection
- Preservative used
- Sample collector's initials
- Analysis required

After it is labeled, each soil sample will be refrigerated or placed in a cooler that contains ice to maintain the sample temperature at 4 °C plus or minus 2 °C.

TABLE 9

SAMPLE CONTAINER, HOLDING TIME, AND PRESERVATIVE REQUIREMENTS

Parameter	Method Number	Sample Volume	Sample Container	Preservative	Holding Time ^a
SOLID					
VOCs	CLP VOC – low level	Three 5-gram aliquots	3 EnCore™ samplers	Cool, 4 ± 2 °C	48 hours
SVOCs	CLP SVOC – low level	8 oz.	Clear glass with Teflon-lined lid	Cool, 4 ± 2 °C	14 days/40 days ^a
Pesticides/PCBs	CLP Pest/PCBs – low level	8 oz.	Clear glass with Teflon-lined lid	Cool, 4 ± 2 °C	14 days/40 days ^a
Chlorinated herbicides	EPA 8151A	8 oz.	Clear glass with Teflon-lined lid	Cool, 4 ± 2 °C	14 days/40 days ^a
Metals	CLP Metals	8 oz.	Clear glass with Teflon-lined lid	Cool, 4 ± 2 °C	14 days/40 days ^a
Metals (WET) ^b	EPA 6010B	8 oz.	Clear glass with Teflon-lined lid	Cool, 4 ± 2 °C	Hg: 28 days Others: 6 months
Metals (TCLP)	EPA 1311/EPA 6010B	8 oz.	Clear glass with Teflon-lined lid	Cool, 4 ± 2 °C	7 days
Fluoride	EPA 340.2	8 oz.	Clear glass with Teflon-lined lid	Cool, 4 ± 2 °C	28 days
pH	EPA 9040/9045A; SW-846	8 oz.	Clear glass with Teflon-lined lid	Cool, 4 ± 2 °C	Hg: 28 days Others: 6 months

TABLE 9 (Continued)

SAMPLE CONTAINER, HOLDING TIME, AND PRESERVATIVE REQUIREMENTS

Parameter	Method Number	Sample Volume	Sample Container	Preservative	Holding Time ^a
AQUEOUS					
VOCs	CLP VOC – low level	120 mL	Three 40 mL VOC vials, butyl/Teflon-lined caps	Sample must be collected without headspace. Preserve with HCl to pH less than or equal to 2 and cool to 4 ± 2° C	14 days (7 days if unpreserved)
SVOCs	CLP SVOC – low level	2 L	Two 1-L amber glass containers	Unpreserved Cool to 4 ± 2° C	7 days
Pesticides/PCBs	CLP Pest/PCBs – low level	2 L	Two 1-L amber glass containers	Unpreserved Cool to 4 ± 2° C	7 days
Chlorinated herbicides	EPA 8151A	2 L	Two 1-L amber glass containers	Unpreserved Cool to 4 ± 2° C	14 days
Metals (Total)	CLP Metals	500 mL	One 500 mL polyethylene container	Field-filtered (to 0.45 µm) Preserve with HNO ₃ to pH < 2 and cool to 4° C	Hg: 28 days Others: 6 months
Mercury	EPA Method 1631	500 mL	One 500 mL polyethylene container	Preserve with HCl to pH < 2 and cool to 4 ± 2° C	28 days
pH	EPA 9040/9045C	250 mL	Clear Glass with Teflon	Cool, 4 ± 2° C	2 days
Fluoride	EPA 340.2	250 mL	250 mL polyethylene container	Cool, 4 ± 2° C	28 days

TABLE 9 (Continued)

SAMPLE CONTAINER, HOLDING TIME, AND PRESERVATIVE REQUIREMENTS

Notes:

More than one analysis can be performed from the same sample container. The sample quantities listed in the table are the quantities necessary if only the specific analysis is requested. The laboratory will indicate which of the analyses can be performed from the same container, so that a smaller quantity of sample can be collected at each depth. Analyses for characterization of IDW samples are included in the table.

- a "x" days/y" days refers to the maximum number of days from sampling to extraction/the maximum number of days from extraction to analysis
- b The Waste Extraction Test (WET) will be used for the metals analysis of soil IDW as required by the California Code of Regulations, 1990.

°C	Degrees Celsius
HCl	hydrochloric acid
L	Liter
µm	Micron
mL	Milliliter
TCLP	Toxicity characteristic leaching procedure

2.3.3 Sample Documentation

Documentation during sampling is essential to ensure proper sample identification. TtEMI personnel will adhere to the following general guidelines for maintaining field documentation:

- Documentation will be completed in permanent black ink
- All entries will be legible
- Errors will be corrected by crossing out with a single line and then dating and initialing the lineout
- Any serialized documents will be maintained at TtEMI and referenced in the site logbook
- Unused portions of pages will be crossed out, and each page will be signed and dated

Section 1.6.1 includes additional information on how TtEMI will use logbooks to document field activities. The TtEMI field team leader (FTL) is responsible for ensuring that sampling activities are properly documented.

2.3.4 Chain of Custody

TtEMI will use standard sample custody procedures to maintain and document sample integrity during collection, transportation, storage, and analysis. A sample will be considered to be in custody if one of the following statements applies:

- It is in a person's physical possession or view.
- It is in a secure area with restricted access.
- It is placed in a container and secured with an official seal such that the sample cannot be reached without breaking the seal.

Chain-of-custody procedures provide an accurate written record that traces the possession of individual samples from the time of collection in the field to the time of acceptance at the laboratory. The chain-of-custody record (see Appendix C) also will be used to document all samples collected and the analysis requested. Field personnel will record the following information on the chain-of-custody record:

- Project name and number
- Sampling location
- Name and signature of sampler

- Destination of samples (laboratory name)
- Sample identification number
- Date and time of collection
- Number and type of containers filled
- Analysis requested
- Preservatives used (if applicable)
- Filtering (if applicable)
- Sample designation (grab or composite)
- Signatures of individuals involved in custody transfer, including the date and time of transfer
- Airbill number (if applicable)
- Project contact and phone number

Unused lines on the chain-of-custody record will be crossed out. Field personnel will sign chain-of-custody records that are initiated in the field, and the airbill number will be recorded. The record will be placed in a waterproof plastic bag and taped to the inside of the shipping container used to transport the samples. Signed airbills will serve as evidence of custody transfer between field personnel and the courier as well as between the courier and the laboratory. Copies of the chain-of-custody record and the airbill will be retained and filed by field personnel before the containers are shipped.

Laboratory chain of custody begins when samples are received and continues until samples are discarded. Laboratories analyzing samples under TtEMI's Government Contracts basic ordering agreement must follow custody procedures at least as stringent as are required by the EPA CLP SOW (EPA 1999a, 2000a). The laboratory should designate a specific individual as the sample custodian. The custodian will receive all incoming samples, sign the accompanying custody forms, and retain copies of the forms as permanent records. The laboratory sample custodian will record all pertinent information concerning the samples, including the following:

- Persons delivering the samples
- Date and time received
- Sample condition at the time of receipt (sealed, unsealed, or broken container; temperature; or other relevant remarks)
- Sample identification numbers

- Unique laboratory identification numbers for the samples

This information should be entered into a computerized LIMS. When the sample transfer process is complete, the custodian is responsible for maintaining internal logbooks, tracking reports, and other records necessary to maintain custody throughout sample preparation and analysis.

The laboratory will provide a secure storage area for all samples. Access to this area will be restricted to authorized personnel. The custodian will ensure that samples requiring special handling, including samples that are heat- or light-sensitive, radioactive, or have other unusual physical characteristics, will be properly stored and maintained before analysis.

2.3.5 Sample Shipment

The following procedures (also outlined in SOP 19, "Packing and Shipping Samples [Appendix B]) will be implemented when soil and water samples collected during this project are shipped:

- The cooler will be filled with bubble wrap, sample bottles, and packing material. Sufficient packing material will be used to prevent sample containers from breaking during shipment. Enough ice will be added to maintain the sample temperature of below 4 plus or minus 2 °C.
- The chain-of-custody records will be placed inside a plastic bag. The bag will be sealed and taped to the inside of the cooler lid. The air bill, if required, will be filled out before the samples are handed over to the carrier. The laboratory will be notified if the sampler suspects that the sample contains any substance that would require laboratory personnel to take safety precautions.
- The cooler will be closed and taped shut with strapping tape around both ends. If the cooler has a drain, it will be taped shut both inside and outside of the cooler.
- Signed and dated custody seals will be placed on the front and side of each cooler. Wide clear tape will be placed over the seals to prevent accidental breakage.
- The chain-of-custody record will be transported within the taped sealed cooler. When the cooler is received at the analytical laboratory, laboratory personnel will open the cooler and sign the chain-of-custody record to document transfer of samples.

Multiple coolers may be sent in one shipment to the laboratory. The outside of the coolers will be marked to indicate the number of coolers in the shipment.

Table 9 presents the analytical methods that will be used to analyze samples collected during this project, and Appendix A presents the MQOs and control limits for sample analysis. Tables D-1 through D-4 in Appendix D present the individual target analytes for this investigation and their associated PRRLs. The analytical laboratories will attempt to achieve the PRRLs for all the investigative samples collected. If problems occur in achieving the PRRLs, the laboratories will contact the TtEMI analytical coordinator immediately, and other alternatives will be pursued (such as analyzing an undiluted aliquot and allowing nontarget compound peaks to go off scale) to achieve acceptable reporting limits. In addition, results below the reporting limit but above the MDL will be reported with appropriate flags to indicate the greater uncertainty associated with these values.

Protocols for laboratory selection and for ensuring laboratory compliance with project analytical and QA/QC requirements are presented in the following text.

2.4.1 Selection of Analytical Laboratories

Laboratories for this investigation will be selected from a list of prequalified laboratories under TtEMI's Government Contracts basic ordering agreement (TtEMI 2002a). Prequalification streamlines laboratory selection by reducing the need to compile and review detailed bid and qualification packages for each individual investigation. Prequalification also improves flexibility in the program by allowing analyses to be directed to a number of different capable laboratories with available capacity at the time samples are collected.

TtEMI's laboratory prequalification and selection process relies on (1) a standard procedure to evaluate and prequalify laboratories for work under the contract and (2) the "Tetra Tech EM Inc. Laboratory Analytical Statement of Work" for TtEMI's Government Contracts basic ordering agreement (TtEMI 2002a), a contractual document that specifies standard requirements for analyses routinely conducted. TtEMI establishes a basic ordering agreement that incorporates and enforces the laboratory SOW with each prequalified laboratory. Individual purchase orders can then be written for specific investigations. These aspects of laboratory selection are further described in the following text, along with TtEMI's procedures for selecting laboratories when the laboratory SOW does not specifically address project-specific analytical methods or QC requirements.

2.4.1.1 Laboratory Evaluation and Prequalification

Laboratories that support the Navy either directly or through subcontracts are evaluated and approved for Navy use by the Naval Facilities Engineering Service Center (NFESC). Laboratories that support TtEMI under TtEMI's Government Contracts basic ordering agreement have been selected from the list of laboratories approved by NFESC and evaluated by TtEMI to assure that the laboratory can meet the technical requirements of the laboratory SOW and produce data of acceptable quality. The laboratory evaluation includes the following elements:

Certification and approval. Laboratories must be currently certified by DHS Environmental Laboratory Accreditation Program (ELAP) for analysis of hazardous materials for each method specified. Laboratories must also have or obtain similar approval from NFESC. The DHS ELAP certification and NFESC approval must be obtained before the laboratory begins work.

Performance evaluation (PE) samples. Each laboratory must initially and yearly demonstrate its ability to satisfactorily analyze single-blind PE samples for all analytical services it will provide under TtEMI's Government Contracts basic ordering agreement. At its discretion, TtEMI may submit one or more double-blind PE samples at TtEMI's cost. When the results for the PE sample are deficient, the laboratory must correct any problems and analyze (at its own cost) a subsequent round of PE samples for the deficient analysis.

Audits. Laboratories must initially and yearly demonstrate their qualifications by submitting to one or more audits by TtEMI. The audits may consist of (1) an on-site review of laboratory facilities, personnel, documentation, and procedures or (2) an off-site review of hard copy and electronic deliverables or magnetic tapes. When deficiencies are identified, the laboratory must correct the problem and provide TtEMI with a written summary of the corrective action taken.

TtEMI currently has five subcontractor laboratories that have passed this evaluation program. These laboratories are listed in Appendix E. Each laboratory was evaluated before it was added to the list, and each is reevaluated annually. If a laboratory fails to meet any of the evaluation criteria, it is removed from the list of approved laboratories.

2.4.1.2 TtEMI's Government Contracts Basic Ordering Agreement Laboratory Statement of Work

The laboratory SOW (TtEMI 2002a) establishes standard requirements for the analytical methods that are most commonly used under TtEMI's Government Contracts basic ordering agreement. For each method, the laboratory SOW specifies standard method-specific target analyte lists and PRRLs; QC samples and associated control limits; calibration requirements; and miscellaneous method performance requirements. The laboratory SOW also specifies standard data package requirements, EDD formats, data qualifiers, and delivery schedules. In addition, the laboratory SOW outlines support services (such as providing sample

containers, trip blanks, temperature blanks, sample coolers, and custody forms and seals) expected of laboratories. The laboratory SOW incorporates Navy QA policy as well as applicable EPA and state QA guidelines, as appropriate.

TtEMI's laboratory SOW is based on EPA CLP methods for VOCs, SVOCs, pesticides, PCBs, metals, and cyanide. The laboratory SOW also addresses frequently used non-CLP methods for a variety of organic, inorganic, and physical parameters. Non-CLP methods include the methods published in the following sources:

- "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), Update III" (EPA 1996a)
- "Methods for Chemical Analysis of Water and Waste" (MCAWW) (EPA 1983)
- American Society for Testing and Materials methods
- American Public Health Association
- American Water Works Association
- "Standard Methods for the Examination of Water and Waste Water" (American Public Health Association, American Water Works Association, and Water Environment Federation 1998)

Laboratories on TtEMI's approved laboratory list can elect to provide all or a portion of the analytical services specified in the laboratory SOW.

As noted previously, the laboratory SOW is incorporated into all laboratory subcontracts established for TtEMI's Government Contracts basic ordering agreement. Thus, the prequalified laboratories commit to meeting the requirements in the laboratory SOW during the contracting process before they receive samples. TtEMI reviews and revises the laboratory SOW regularly to incorporate new methods and requirements, modifications or updates to existing methods, changes in Navy QA policy or regulatory requirements, and any other necessary corrections or revisions.

2.4.1.3 Laboratory Selection and Oversight

After project-specific analytical and QA/QC requirements have been identified and documented in the SAP, the TtEMI analytical coordinator works closely with a TtEMI procurement specialist to select a laboratory that can meet these requirements. When project-specific analytical and QC requirements are consistent with TtEMI's laboratory SOW, the analytical coordinator identifies one or more prequalified subcontractor laboratories that are capable of carrying out the work. As part of this process,

the analytical coordinator typically contacts the laboratories to discuss the analytical requirements and project schedule. The analytical coordinator then forwards the name of the recommended laboratory (or laboratories) to the TtEMI procurement specialist, who issues a purchase order for the work. When analytical requirements are consistent with TtEMI's laboratory SOW and multiple prequalified laboratories are capable of performing the work, a specific laboratory is typically selected based on laboratory workload and project schedule considerations.

TtEMI follows a similar procedure when project-specific analytical and QC requirements are nonstandard and differ from those specified in TtEMI's laboratory SOW. The analytical coordinator contacts analytical laboratories, beginning with those on TtEMI's prequalified list, to discuss the analytical and QA/QC requirements in the SAP and to assess the laboratories' ability to meet the requirements. In many cases, TtEMI works cooperatively with analytical laboratories to develop and refine appropriate QC requirements for nonstandard analyses or matrixes.

If the analytical coordinator is unable to identify one or more prequalified laboratories that can perform the work, additional laboratories are contacted. In general, the additional laboratories must be evaluated as described in Section 2.4.1.1 before they will be allowed to analyze any samples. Some steps in the evaluation may be waived for certain investigations and circumstances (for example, unusual analytes, urgent project needs, experimental methods, mobile laboratories, or on-site screening analysis). After additional laboratories have been identified, the analytical coordinator forwards their names to the procurement specialist. The procurement specialist prepares a solicitation package, including the project-specific analytical and QC requirements, and submits the package to the laboratories. The procurement specialist, in cooperation with the analytical coordinator and project manager, then evaluates the proposals received and selects a laboratory that meets the requirements and provides the best value to TtEMI and the Navy. Finally, the procurement specialist issues a purchase order to the selected laboratory that incorporates the project-specific analytical and QA/QC requirements.

After a laboratory has been selected, the analytical coordinator holds a kickoff meeting with the laboratory project manager. The kickoff meeting is held regardless of whether project-specific analytical and QA/QC requirements are consistent with TtEMI's laboratory SOW or are outside the SOW. The TtEMI project manager, procurement specialist, and other key project and laboratory staff may also be involved in this meeting. The kickoff meeting includes a review of analytical and QC requirements in the SAP, the project schedule, and any other logistical support that the laboratory will be expected to provide.

2.4.2 Project Analytical Requirements

For this investigation, one or more prequalified subcontractor laboratories will analyze samples of soil and water off site. The laboratories will be selected before the field program begins based on their ability to meet the project analytical and QC requirements as well as their ability to meet the project schedule. The analytical methods selected for the investigation at AOC 1 are standard EPA methods described in TtEMI's Government Contracts basic ordering agreement (TtEMI 2002a).

This SAP documents project-specific QC requirements for the selected analytical methods. Sample volume, preservation, and holding time requirements are specified in Table 9. Requirements for laboratory QC samples are described in Table 4 and in Section 2.5. Appendix A includes project-specific precision and accuracy goals for the methods. Finally, project-required reporting limits for each method are documented in Appendix D.

2.5 QUALITY CONTROL

TtEMI will assess the quality of field data through regular collection and analysis of field QC samples. Laboratory QC samples will also be analyzed in accordance with referenced analytical method protocols to ensure that laboratory procedures and analyses are conducted properly and that the quality of the data is known.

2.5.1 Field Quality Control Samples

QC samples are collected in the field and analyzed to check sampling and analytical precision, accuracy, and representativeness. The following section discusses the types and purposes of field QC samples that will be collected for this project. Table 10 provides a summary of the types and frequency of collection of field QC samples.

TABLE 10
FIELD QUALITY CONTROL SAMPLES

Sample Type	Frequency of Analysis	Matrix
Field duplicate	10 percent	Water
Equipment rinsate	1 per day per team per type of reusable sampling tool used	Water
Trip blanks	1 per cooler containing samples for VOC analysis	Soil and Water

2.5.1.1 Field Duplicates

Field duplicate samples are collected at the same time and from the same source and then submitted as separate samples to the laboratory for analysis. Although field duplicate soil samples are sometimes collected as soil samples from adjacent locations, duplicate samples for soil will not be collected for this project for two reasons. First, because adjacent soil samples incorporate some spatial variability, these samples cannot be used directly to assess sampling precision. Furthermore, it is not practical to set QC limits for the RPD of these samples, which precludes their use for QC purposes. Second, while the information on spatial variability that can be obtained from adjacent soil samples may be useful in assessing or implementing remedial options, no objectives relating to these data uses have been identified for this project. Rather, it has been determined that this type of information on spatial variability will be obtained during subsequent investigations at this site, if deemed necessary.

2.5.1.2 Field Blanks

Contamination can be introduced from many external sources during collection of field samples. Field blanks will be collected based on field conditions (that is, if either winds or construction that create dust are encountered during sampling). It is not expected that field blanks will be collected at the site. If they are collected, field blank samples will consist of sample containers filled with analyte-free water. Analytically certified, organic-free water or equivalent will be used for organic parameters; deionized or distilled water will be used for inorganic parameters.

If any contaminant is present in the blank samples above the MDL, the result for associated field samples that contain the same contaminant will be qualified as potentially not detected if the concentration of the field sample is less than 5 times the concentration found in the blank.

2.5.1.3 Trip Blanks

The purpose of a trip blank is to demonstrate that contamination is not originating from sample containers or from any factor during the transport of samples. A trip blank originates at the laboratory as a 40-milliliter (mL) vial used for VOC analysis. The vial is filled at the laboratory with reagent grade, organic free water. The trip blanks are stored at the site until the proposed field samples have been collected. One trip blank will accompany each sample transport container that contains water samples for TPH-p analysis back to the laboratory. The trip blank is not opened until it is returned to the laboratory at the time of analysis. Trip blanks are only analyzed for VOCs.

2.5.1.4 Equipment Rinsate Samples

Equipment rinsate samples will be collected during soil and groundwater sampling at a frequency of once per day of sampling per team per type of tool used. An equipment rinsate is a sample collected after a sampling device is subjected to standard decontamination procedures. Water will be poured over or through the sampling equipment into a sample container and sent to the laboratory for analysis. Analytically certified, organic-free water or equivalent will be used for organic parameters; deionized or distilled water will be used for inorganic parameters.

During data validation, the results for the equipment rinsate samples will be used to qualify data or to evaluate the concentrations of analytes in the field samples collected on the same day.

2.5.1.5 Source Water Blank Samples

One source water blank will be collected for each sampling event and for each source of water (distilled, deionized, or from an industrial or residential water source). For the investigation at AOC 1, only one source water blank will be needed to characterize the deionized water used as rinse water in the final stage of equipment decontamination.

2.5.2 Laboratory Quality Control Samples

The types of laboratory QC samples to be used for this project are discussed in the following text. Table 4 presents the required frequencies for laboratory QC samples, and Appendix A presents project-specific precision and accuracy goals for these samples.

2.5.2.1 Method Blanks

Method blanks will be prepared at the frequency prescribed in the individual analytical method or at a rate of 5 percent of the total samples if a frequency is not prescribed in the method.

2.5.2.2 Matrix Spike and Matrix Spike Duplicates

MS/MSD samples require collection of an additional volume of material for laboratory spiking and analysis. MS/MSD samples will be collected at a frequency of 5 percent for soil and groundwater samples. The percent recoveries will be calculated for each of the spiked analytes and used to evaluate

analytical accuracy. The RPD between spiked samples will be calculated to evaluate precision. Project-specific precision and accuracy goals are presented in Appendix A.

2.5.2.3 Laboratory Control Samples or Blank Spikes

LCSs will be analyzed at the frequency prescribed in the analytical method or at a rate of 5 percent of the total samples if a frequency is not prescribed in the method. If percent recovery results for the LCS or blank spike are outside of the established goals, laboratory-specific protocols will be followed to gauge the usability of the data.

2.5.2.4 Surrogate Standards

Surrogate standards consist of known concentrations of nontarget organic analytes added to each sample, method blank, and MS/MSD before samples are prepared and analyzed. The surrogate standard measures the efficiency of the analytical method in recovering the target analytes from an environmental sample matrix. Percent recoveries for surrogate compounds are evaluated using laboratory control limits. Surrogate standards provide an indication of laboratory accuracy and matrix effects for every field and QC sample analyzed for volatile and extractable organic constituents. Surrogate compounds are used in the analysis of VOCs to monitor purge efficiency and analytical performance, whereas surrogates are used in the analysis of extractable organic compounds to monitor the extraction process and analytical performance.

2.5.2.5 Internal Standards

Internal standards are compounds added to every VOC and SVOC standard, method blank, MS/MSD, and sample or sample extract at a known concentration before analysis. Internal standards are used as the basis for quantification of gas chromatography and mass spectrometry (GC/MS) target compounds and ensure that the GC/MS sensitivity and response are stable during the analytical run. An internal standard is used to evaluate the efficiency of the sample introduction process and monitors the efficiency of the analytical procedure for each sample matrix encountered. Internal standards may also be used in the analysis of organic compounds by GC to monitor retention-time shifts. Validation of internal standards data will be based on EPA protocols presented in guidelines for evaluating organic analyses (EPA 1999b).

2.5.3 Additional Laboratory Quality Control Procedures

In addition to the analysis of laboratory QC samples, subcontractor laboratories will conduct the QC procedures discussed in the following text.

2.5.3.1 Method Detection Limit Studies

The MDL is the minimum concentration of a compound that can be measured and reported. The MDL is a specified limit at which there is 99 percent confidence that the concentration of the analyte is greater than zero. The MDL takes into account sample matrix and preparation. The subcontractor laboratory will demonstrate the MDLs for all analyses except inorganic analyses and physical properties test methods.

MDL studies will be conducted annually for soil matrices or more frequently if any method or instrumentation changes. Each MDL study will consist of seven replicates spiked with all target analytes of interest at concentrations no greater than required quantitation limits. The replicates will be extracted and analyzed in the same manner as routine samples. If multiple instruments are used, each will be included in the MDL study. The MDLs reported will be representative of the least sensitive instrument.

2.5.3.2 Sample Quantitation Limits

Sample quantitation limits (SQL), also referred to as practical quantitation limits, are PRRLs adjusted for the characteristics of individual samples. The PRRLs presented in Appendix D are chemical-specific concentrations that a laboratory should be able to routinely detect and quantitate in a given sample matrix. The PRRL is usually defined in the analytical method or in laboratory method documentation. The SQL takes into account changes in the preparation and analytical methodology that may alter the ability to detect an analyte, including changes such as use of a smaller sample aliquot or dilution of the sample extract. Physical characteristics such as sample matrix and percent moisture that may alter the ability to detect the analyte are also considered. The laboratory will calculate and report SQLs for all environmental samples.

2.5.3.3 Control Charts

Control charts document data quality in graphic form for specific method parameters such as surrogates and blank spike recoveries. A collection of data points for each parameter is used to statistically calculate means and control limits for a given analytical method. This information is useful in determining whether analytical measurement systems are in control. In addition, control charts provide information about trends over time in specific analytical and preparation methodologies. Although they are not required, TtEMI recommends that subcontractor laboratories maintain control charts for organic and inorganic analyses. At a minimum, method-blank surrogate recoveries and blank spike recoveries should be charted for all organic methods. Blank spike recoveries should be charted for inorganic methods. Control charts should be updated monthly.

2.6 EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

This section outlines the testing, inspection, and maintenance procedures to be used to keep both field and laboratory equipment in good working condition.

2.6.1 Maintenance of Field Equipment

Preventive maintenance for most field equipment is carried out in accordance with procedures and schedules recommended in (1) the equipment manufacturer's literature or operating manual or (2) SOPs that describe equipment operation associated with particular applications of the instrument. More stringent testing, inspection, and maintenance procedures and schedules may be required when field equipment is used to make critical measurements.

A field instrument that is out of order will be segregated, clearly marked, and not used until it is repaired. The field team leader will be notified of equipment malfunctions so that prompt service can be completed quickly or substitute equipment can be obtained. When the condition of equipment is suspect, unscheduled testing, inspection, and maintenance should be conducted. Any significant problems with field equipment will be reported in the daily field QC report.

A Geoprobe will be used to collect soil samples during the investigation at AOC 1. The Geoprobe subcontractor will make detailed written procedures for inspecting, maintaining, and servicing field equipment available on site. At a minimum, these procedures should address standard Geoprobe maintenance outlined in TtEMI SOP 054, "Using the Geoprobe System" (Appendix B).

2.6.2 Maintenance of Laboratory Equipment

Subcontractor laboratories will prepare and follow a maintenance schedule for each instrument used to analyze samples collected from AOC 1. All instruments will be serviced at scheduled intervals necessary to optimize factory specifications. Routine preventive maintenance and major repairs will be documented in a maintenance logbook.

An inventory of items to be kept ready for use in case of instrument failure will be maintained and restocked as needed. The list will include equipment parts subject to frequent failure, parts that have a limited lifetime of optimum performance, and parts that cannot be obtained in a timely manner.

The laboratory's QA plan and written SOPs will describe specific preventive maintenance procedures for equipment maintained by the laboratory. These documents identify the personnel responsible for major, preventive, and daily maintenance procedures; the frequency and type of maintenance performed; and procedures for documenting maintenance activities.

Laboratory equipment malfunctions will require immediate corrective action. Actions should be documented in laboratory logbooks. No other formal documentation is required unless data quality is adversely affected or further corrective action is necessary. On-the-spot corrective actions will be taken as necessary in accordance with the procedures described in the laboratory QA plan and SOPs.

2.7 INSTRUMENT CALIBRATION AND FREQUENCY

The following sections discuss calibration procedures that will be followed to ensure the accuracy of measurements made using field and laboratory equipment.

2.7.1 Calibration of Field Equipment

Field equipment, if used, will be calibrated at the beginning of the field effort and at prescribed intervals. The calibration frequency depends on the type and stability of equipment, the intended use of the equipment, and the recommendation of the manufacturer. Detailed calibration procedures for field equipment are available from the specific manufacturers' instruction manuals. All calibration information will be recorded in a field logbook or on field forms. A label that specifies the scheduled date of the next calibration will be attached to the field equipment. If this type of identification is not feasible, equipment calibration records will be readily available for reference.

2.7.2 Calibration of Laboratory Equipment

Procedures and frequencies for calibration of laboratory equipment will follow the requirements in the reference method in Section 2.4 of this SAP. Qualified analysts will calibrate laboratory equipment and document the procedures and results in a logbook.

The laboratory will obtain calibration standards from the EPA repository or commercial vendors for both inorganic and organic compounds and analytes. Stock solutions for surrogate parameters and other inorganic mixes will be made from reagent-grade chemicals or as specified in the analytical method. Stock standards will also be used to make intermediate standards for preparing calibration standards. Special attention will be paid to expiration dating, proper labeling, proper refrigeration, and freedom from contamination. Documentation on receipt, mixing, and use of standards will be recorded in the appropriate laboratory logbook. Logbooks must be permanently bound. Additional specific handling and documentation requirements for the use of standards may be provided in subcontractor laboratory QA plans.

2.8 INSPECTION AND ACCEPTANCE OF SUPPLIES AND CONSUMABLES

TtEMI project managers have primary responsibility for identifying the types and quantities of supplies and consumables needed to complete AECRU projects and are responsible for determining acceptance criteria for these items.

Supplies and consumables can be received either at a TtEMI office or at a work site. When supplies are received at an office, the project manager or field team leader will sort them according to vendor, check packing slips against purchase orders, and inspect the condition of all supplies before they are accepted for use on a project. If an item does not meet the acceptance criteria, deficiencies will be noted on the packing slip and purchase order, and the item will then be returned to the vendor for replacement or repair.

Procedures for receiving supplies and consumables in the field are similar. When supplies are received, the TtEMI project manager or FTL will inspect all items against the acceptance criteria. Any deficiencies or problems will be noted in the field logbook, and deficient items will be returned for immediate replacement.

Analytical laboratories are required to provide certified clean containers for all analyses. These containers must meet EPA standards described in "Specifications and Guidance for Obtaining Contaminant-Free Sampling Containers" (EPA 1992).

2.9 NONDIRECT MEASUREMENTS

No data for project implementation or decision-making will be obtained from nondirect measurement sources.

2.10 DATA MANAGEMENT

Field and analytical data collected from this project and other environmental investigations at AOC 1 are critical to site characterization efforts, development of the comprehensive conceptual site model, risk assessments, and selection of remedial actions to protect human health and the environment. An information management system is necessary to ensure efficient access so that decisions based on the data can be made in a timely manner.

After the field and laboratory data reports are reviewed and validated, the data will be entered into TtEMI's database for AOC 1. The database contains data that (1) summarize observations on contamination and geologic conditions, (2) may be used to prepare reports and graphics, (3) may be used with geographic information systems, and (4) may be transmitted in an electronic format compatible with NEDTS. The following sections describe TtEMI's data tracking procedures, data pathways, and overall data management strategy for AOC 1.

2.10.1 Data-Tracking Procedures

All data generated in support of the AECRU program at AOC 1 are tracked through a database created by TtEMI. Information related to the receipt and delivery of samples, project order fulfillment, and invoicing for laboratory and validation tasks is stored in the TtEMI program, SAMTRAK. All data are filed according to the document control number.

2.10.2 Data Pathways

Data are generated from three primary pathways at AOC 1: field activities, laboratory analysis, and validation. Data from all three pathways must be entered into the NWSSB Concord database. Data

pathways must be established and well documented to evaluate whether the data have been accurately loaded into the database in a timely manner.

Data generated during field activities are recorded using field forms (Appendix C). The analytical coordinator or field team leader reviews these forms for completeness and accuracy. Data from the field forms, including the chain-of-custody form, are entered into SAMTRAK according to the document control number.

Data generated during laboratory analysis are recorded in hard copy and in EDDs after the samples have been analyzed. The laboratory will send the hard copy and EDDs records to the analytical coordinator. The analytical coordinator reviews the data deliverable for completeness, accuracy, and format. After the format has been approved, the electronic data are manipulated and downloaded into the NWSSB Concord database. TtEMI data entry personnel will then update SAMTRAK with the total number of samples received and number of days required to receive the data.

After validation, the analytical coordinator reviews the data for accuracy. TtEMI will then update the NWSSB Concord database with the appropriate data qualifiers. SAMTRAK is also updated to record associated laboratory and data validation costs.

2.10.3 Data Management Strategy

TtEMI's short- and mid-term data management strategies require that the database for NWSSB Concord be updated monthly. The data consist of chemical and field data from Navy contractors, entered into an Oracle (Version 7.3) database. The database can be used to generate reports using available computer-aided drafting, design, and contouring software. All electronic data from this database will be transmitted in a format compatible with NEDTS.

To satisfy long-term data management goals, the data will be loaded into the database at TtEMI for storage, further manipulation, and retrieval after the off-site laboratory and field reports are reviewed and validated. The database will be used to provide data for chemical and geologic analysis and for preparing reports and graphic representations of the data. Additional data acquired from field activities are recorded on field forms (Appendix C), reviewed for completeness and accuracy by the analytical coordinator or FTL. Hard copies of forms, data, and chain-of-custody forms are filed in a secure storage area according to project and document control numbers. Laboratory data packages and reports will be archived at TtEMI or Navy offices. Laboratories that generated the data will archive hard copy data for a minimum of 10 years.

3.0 ASSESSMENT AND OVERSIGHT

This section describes the field and laboratory assessments that may be conducted during this project, the individuals responsible for conducting assessments, corrective actions that may be implemented in response to assessment results, and how quality-related issues will be reported to TtEMI and Navy management.

3.1 ASSESSMENT AND RESPONSE ACTIONS

TtEMI and the Navy will oversee collection of environmental data using the assessment and audit activities described in the following text. Any problems encountered during an assessment of field investigation or laboratory activities will require appropriate corrective action to ensure that the problems are resolved. This section describes the types of assessments that may be completed, TtEMI and Navy responsibilities for conducting the assessments, and corrective action procedures to address problems identified during an assessment.

3.1.1 Field Assessments

TtEMI conducts field assessments to support data quality and encourage continuous improvement in the systems that support environmental data collection. TtEMI procedures for conducting field assessments are documented in a "Draft Field Assessment Plan for Comprehensive Long-term Environmental Action Navy (CLEAN II)" (TtEMI 2000b). Technical systems audits (TSA) are the type of field assessment most frequently conducted. TtEMI personnel who conduct TSAs use personnel interviews, direct observations, and reviews of project-specific documentation to evaluate and document whether procedures specified in the approved SAP are being implemented. The following specific items may be observed during the TSA:

- Availability of project plans such as the SAP and HASP
- Documentation of personnel qualifications and training
- Sample collection, identification, preservation, handling, and shipping procedures
- Sampling equipment decontamination
- Equipment calibration and maintenance
- Completeness of logbooks and other field records (including nonconformance documentation)
- Health and safety procedures

During the TSA, the lead TtEMI assessor verbally communicates any significant deficiencies to the FTL for immediate correction. These and all other observations and comments are documented in a draft TSA report. The draft TSA report is issued to the Navy QA officer and remedial project manager (RPM) as well as to the TtEMI project manager, FTL, program QA manager, and project QA officer in electronic (e-mail) format within 7 days after the TSA is completed. Project teams are required to respond to the draft report within 3 days, and a final TSA report is issued within 7 days after the project team responds.

The TtEMI program QA manager determines the frequency and duration of TSAs. Generally, TSAs are conducted early in the project so that quality issues can be resolved before large amounts of data are collected. The TtEMI program QA manager will notify the Navy QA officer and RPM before a TSA is conducted so that they may attend the TSA and observe the field assessment.

The Navy QA officer may also independently conduct a field assessment of any TtEMI project. Items reviewed by the Navy QA officer during a field assessment would be similar to those described previously.

The TtEMI program QA manager, in conjunction with the Navy QA officer, selects which AECRU projects will receive a TSA. A schedule of field activities and planned TSAs is maintained and updated bimonthly. Projects to receive TSAs are not firmly identified until field sampling activities are initiated so that scheduling issues can be addressed.

3.1.2 Laboratory Assessments

As described in Section 2.4.1, NFESC and TtEMI assess all laboratories that analyze samples collected under the AECRU contract. These assessments include (1) reviews of laboratory certifications, (2) initial and annual demonstrations of the laboratory's ability to satisfactorily analyze single-blind PE samples, and (3) laboratory audits. Laboratory audits may consist of an on-site review of laboratory facilities, personnel, documentation, and procedures or an off-site evaluation of the ability of the laboratory's data management system to meet contract requirements. TtEMI also conducts project-specific laboratory assessments when an approved laboratory has been selected for nonroutine analyses or when a laboratory not on the approved list must be used. These assessments typically require laboratory analysis of PE samples.

The Navy may audit any laboratory that will analyze samples on this project. The Navy QA officer will determine the need for these audits and will typically conduct the audits before samples are submitted to the laboratory for analysis.

3.1.3 Assessment Responsibilities

TtEMI personnel who conduct assessments will be independent of the activity evaluated. The TtEMI program QA manager will select the appropriate personnel to conduct each assessment and will assign them responsibilities and deadlines for completing the assessment. These personnel may include the program QA manager, project QA officer, or senior technical staff with relevant expertise and experience in assessment.

When an assessment is planned, the TtEMI program QA manager selects a lead assessor who is responsible for the following:

- Selecting and preparing the assessment team
- Preparing an assessment plan
- Coordinating and scheduling the assessment with the project team, subcontractor, or other organization being evaluated
- Participating in the assessment
- Coordinating preparation and issuance of assessment reports and corrective action request forms
- Evaluating responses and resulting corrective actions.

After the assessment is completed, the lead assessor will submit an audit report to the Navy QA officer and RPM as well as to the TtEMI program QA manager, project manager, and project QA officer; other personnel may be included in the distribution as appropriate. Assessment findings will also be included in the QC summary report for the project (see Section 3.2.3).

The Navy QA officer is responsible for coordinating all audits that may be conducted by Navy personnel under this project. Audit preparation, completion, and reporting responsibilities for Navy auditors would be similar to those described previously.

3.1.4 Field Corrective Action Procedures

Field corrective action procedures will depend on the type and severity of the finding. TtEMI classifies assessment findings as either deficiencies or observations. Deficiencies are findings that may have a significant impact on data quality and that will require corrective action. Observations are findings that do not directly affect data quality. They are suggestions for consideration and review.

As described in Section 3.1.1, project teams are required to respond to deficiencies identified in TSA reports. The project manager, FTL, and project QA officer will meet to discuss the deficiencies and the appropriate steps to resolve each deficiency through the following actions:

- Determining when and how the problem developed
- Assigning responsibility for problem investigation and documentation
- Selecting the corrective action to eliminate the problem
- Developing a schedule for completing the corrective action
- Assigning responsibility for implementing the corrective action
- Documenting and verifying that the corrective action has eliminated the problem
- Notifying the Navy of the problem and the corrective action taken

In responding to the TSA report, the project team will include a brief description of each deficiency, the proposed corrective action, the individual responsible for determining and implementing the corrective action, and the completion dates for each corrective action. The project QA officer will use a status report to monitor the status of all corrective actions.

The TtEMI program QA manager is responsible for reviewing proposed corrective actions and verifying that they have been effectively implemented. The program QA manager can require data acquisition to be limited or discontinued until the corrective action is complete and a deficiency is eliminated. The program QA manager can also request the reanalysis of any or all data acquired since the system was last in control.

3.1.5 Laboratory Corrective Action Procedures

Internal laboratory procedures for corrective action and descriptions of out-of-control situations that require corrective action are contained in laboratory QA plans. At a minimum, corrective action will be implemented when any of the following three conditions occurs: control limits are exceeded, method QC requirements are not met, or sample-holding times are exceeded. The laboratory will report out-of-control situations to the TtEMI analytical coordinator within 2 working days after they are identified. In addition, the laboratory project manager will prepare and submit a corrective action report to the TtEMI analytical coordinator. This report will identify the out-of-control situation and the steps that the laboratory has taken to rectify it.

3.2

REPORTS TO MANAGEMENT

Effective management of environmental data collection requires (1) timely assessment and review of all activities and (2) open communication, interaction, and feedback among all project participants. TtEMI will use the reports described in the following text to address any project-specific quality issues and to facilitate timely communication of these issues.

3.2.1 Daily Progress Reports

TtEMI will prepare a daily progress report to summarize activities throughout the field investigation. This report will describe sampling and field measurements, equipment used, TtEMI and subcontractor personnel on site, QA/QC and health and safety activities, problems encountered, corrective actions taken, deviations from the SAP, and explanations for the deviations. The daily progress report is prepared by the FTL and submitted to the project manager and to the Navy RPM, if requested. The content of the daily reports will be summarized and included in the final report submitted for the field investigation.

3.2.2 Project Monthly Status Report

The TtEMI project manager will prepare a monthly status report (MSR) to be submitted to the TtEMI's AECRU program manager and the Navy RPM. MSRs address project-specific quality issues and facilitate their timely communication. The MSR will include the following quality-related information:

- Project status
- Instrument, equipment, or procedural problems that affect quality and recommended solutions
- Objectives from the previous report achieved
- Objectives from the previous report not achieved
- Work planned for the next month

If appropriate, TtEMI will obtain similar information from subcontractors participating in the project and will incorporate the information into the MSR.

4.0 DATA VALIDATION AND USABILITY

This section describes the procedures that are planned to review, verify, and validate field and laboratory data. This section also discusses procedures for verifying that the data are sufficient to meet DQOs for the project.

4.1 DATA REVIEW, VERIFICATION, AND VALIDATION

Validation and verification of the data generated during field and laboratory activities are essential to obtaining data of defensible and acceptable quality. Verification and validation methods for field and laboratory activities are presented in the following text.

4.1.1 Field Data Verification

Project team personnel will verify field data through reviews of data sets to identify inconsistencies or anomalous values. Any inconsistencies discovered will be resolved as soon as possible by seeking clarification from field personnel responsible for data collection. All field personnel will be responsible for following the sampling and documentation procedures described in this SAP so that defensible and justifiable data are obtained.

Data that are significantly different from the population are called "outliers." A systematic effort will be made to identify any outliers or errors before field personnel report the data. Outliers can result from improper sampling or measurement methodology, data transcription errors, calculation errors, or natural causes. Outliers that result from errors found during data verification will be identified and corrected; outliers that cannot be attributed to errors in sampling, measurement, transcription, or calculation will be clearly identified in project reports.

4.1.2 Laboratory Data Verification

Laboratory personnel will verify analytical data at the time of analysis and reporting and through subsequent reviews of the raw data for any nonconformances to the requirements of the analytical method. Laboratory personnel will make a systematic effort to identify any outliers or errors before they report the data. Outliers that result from errors found during data verification will be identified and corrected; outliers that cannot be attributed to errors in analysis, transcription, or calculation will be clearly identified in the case narrative section of the analytical data package.

4.1.3 Laboratory Data Validation

An independent third-party contractor will validate all laboratory data in accordance with current EPA national functional guidelines (EPA 1994, 1999b). The data validation strategy will be consistent with Navy guidelines. For this project, 80 percent of the data for contaminants of concern will undergo cursory validation, and 20 percent of the data for contaminants of concern will undergo full validation. Requirements for cursory and full validation are listed in the following text. Samples for low-level mercury analysis are subject to special data validation requirements detailed in "Guidance on the Documentation and Evaluation of Trace Metals Data Collected for Clean Water Act Compliance Monitoring" (EPA 1996b).

4.1.3.1 Cursory Data Validation

Cursory validation will be completed on 80 percent of the summary data packages for analysis of contaminants of concern. The data reviewer is required to notify TtEMI and request any missing information needed from the laboratory. Elimination of the data from the review process is not allowed. All data will be qualified as necessary in accordance with established criteria. Data summary packages will consist of sample results and QC summaries, including calibration and internal standard data.

4.1.3.2 Full Data Validation

Full validation will be completed on 20 percent of the full data packages for analysis of contaminants of concern. The data reviewer is required to notify TtEMI and request any missing information needed from the laboratory. Elimination of data from the review process is not allowed. All data will continue through the validation process and will be qualified in accordance with established criteria. Data summary packages will consist of sample results, QC summaries, and all raw data associated with the sample results and QC summaries.

4.1.3.3 Data Validation Criteria

Table 11 lists the QC criteria to be reviewed for both cursory and full data validation. The data validation criteria selected from Table 11 will be consistent with the project-specific analytical methods listed in Section 2.4.

4.2

RECONCILIATION WITH USER REQUIREMENTS

After environmental data have been reviewed, verified, and validated in accordance with the procedures described in Section 4.1, the data must be further evaluated to determine whether DQOs have been met.

TABLE 11
DATA VALIDATION CRITERIA

Analytical Parameter Group	Cursory Data Validation Criteria	Full Data Validation Criteria
Non-CLP Organic Analyses	Method compliance Holding times Calibration Blanks Surrogate recovery Matrix spike and matrix spike duplicate recovery Laboratory control sample or blank spike Internal standard performance Field duplicate sample analysis Other laboratory QC specified by the method Overall assessment of data for an SDG	Method compliance Holding times Calibration Blanks Surrogate recovery Matrix spike and matrix spike duplicate recovery Laboratory control sample or blank spike Internal standard performance Compound identification Detection limits Compound quantitation Sample results verification Other laboratory QC specified by the method Overall assessment of data for an SDG
Non-CLP Inorganic Analyses	Method compliance Holding times Calibration Blanks Matrix spike and matrix spike duplicate recovery Laboratory control sample or blank spike Field duplicate sample analysis Other laboratory QC specified by the method Overall assessment of data for an SDG	Method compliance Holding times Calibration Blanks Matrix spike and matrix spike duplicate recovery Laboratory control sample Field duplicate sample analysis Other laboratory QC specified by the method Detection limits Analyte identification Analyte quantitation Sample results verification Overall assessment of data for an SDG

To the extent possible, TtEMI will follow EPA's data quality assessment (DQA) process to verify that the type, quality, and quantity of data collected are appropriate for their intended use. DQA methods and procedures are outlined in EPA's "Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, QA00 Update" (2000c). The DQA process includes five steps: (1) review the DQOs and sampling design, (2) conduct a preliminary data review, (3) select a statistical test, (4) verify the assumptions of the statistical test, and (5) draw conclusions from the data.

When the five-step DQA process is not completely followed because the DQOs are qualitative, Tetra Tech will systematically assess data quality and data usability. This assessment will include the following:

- A review of the sampling design and sampling methods to verify that these were implemented as planned and are adequate to support project objectives
- A review of project-specific data quality indicators for precision, accuracy, representativeness, completeness, comparability, and quantitation limits (defined in Section 1.3.2) to determine whether acceptance criteria have been met
- A review of project-specific DQOs to determine whether they have been achieved by the data collected
- An evaluation of any limitations associated with the decisions to be made based on the data collected. For example, if data completeness is only 90 percent compared to a project-specific completeness objective of 95 percent, the data may still be usable to support a decision, but at a lower level of confidence.

The final report for the project will discuss any potential impacts of these reviews on data usability and will clearly define any limitations associated with the data.

REFERENCES

- American Public Health Association, American Water Works Association, and Water Environment Federation, 1998. "Standard Methods for the Examination of Water and Wastewater, 20th Edition"
- Dames & Moore. 1988. "Final Preliminary Assessment/Site Inspection of Naval Station Treasure Island." Prepared for the Naval Energy and Environmental Support Activity. April.
- Naval Facilities Engineering Service Center (NFESC). 2001. "Draft Action Memorandum for Area of Concern 1." December 28.
- PRC Environmental Management, Inc. (PRC). 1997. "Draft Final Onshore Remedial Investigation Report, Naval Station Treasure Island, San Francisco, California." September.
- Tetra Tech EM Inc. 1997. "Draft Base-wide Health and Safety Plan, Naval Weapons Station Seal Beach Detachment Concord, Concord, California." November 24.
- Puls, R.W., and R.M. Powell. 1992. "Acquisition of Representative Ground Water Quality Samples for Metals." Ground Water Monitoring Review. Summer. Pages 167-176.
- Regional Water Quality Control Board (RWQCB). 1995. "San Francisco Bay Basin Water Quality Control Plan." California Regional Quality Control Board – San Francisco Bay Region. June 21.
- Tetra Tech EM Inc. (TtEMI). 1999. "Naval Weapons Station Seal Beach Detachment, Concord, Area of Concern 1, Pump Station Area, Preliminary Assessment Report." May 20.
- TtEMI. 2001. "Preliminary Assessment Addendum, Area of Concern 1, Naval Weapons Station, Seal Beach Detachment Concord." September 28.
- TtEMI. 2002a. "Tetra Tech EM Inc. Government Contracts Laboratory Analytical Statement of Work for Indefinite Quantity Contract for Architectural-Engineering Services to Provide CERCLA/RCRA/UST Studies." January.
- TtEMI. 2002b. "Meeting Minutes Naval Weapons Station Seal Beach Detachment Concord Area of Concern 1, December 13, 2001. February 12.
- U.S. Environmental Protection Agency (EPA). 1983. "Methods for Chemical Analysis of Water and Waste."
- EPA. 1992. "Specifications and Guidance for Obtaining Contaminant-Free Sampling Containers." OSWER Directive No. 9240.0-05A. April.
- EPA. 1994. "National Functional Guidelines for Inorganic Data Review." Office of Emergency and Remedial Response. Washington, D.C. EPA-540/R-94/013. February.
- EPA. 1996a. "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), Update III." Office of Solid Waste and Emergency Response. Washington, D.C. December.
- EPA. 1996b. "Guidance on the Documentation and Evaluation of Trace Metals Data Collected for Clean Water Act Compliance Monitoring" EPA-821/B-96-002.

- EPA. 1999a. "U.S. EPA Contract Laboratory Program Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration." Document Number OLM04.2. May.
- EPA. 1999b. "National Functional Guidelines for Organic Data Review." Office of Emergency and Remedial Response. Washington, D.C. EPA-540/R-99-008. October.
- EPA. 1999c. "Screening Level Ecological Risk Assessment Protocol." U.S. EPA Region 6, Office of Solid Waste, Center for Combustion Science and Engineering. August.
- EPA. 2000a. "U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis, Multi-Media, Multi-Concentration." Document Number ILM04.1. January.
- EPA. 2000b. "Data Quality Objectives Process for Hazardous Waste Site Investigations (EPA QA/G-4HW)." Office of Environmental Information. Washington, D.C. EPA/600/R-00/007. January.
- EPA. 2000c. "Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, QA00 Update." Office of Environmental Information. Washington, D.C. EPA/600/R-96-084. July.
- EPA. 2000d. "Guidance for the Data Quality Objectives Process, EPA QA/G-4." Office of Environmental Information. Washington, D.C. EPA/600/R-96/055. August.
- EPA. 2001. "EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5." Office of Environmental Information. Washington, D.C. EPA/240/B-01/003. March
- EPA. 2002a. "Region 9 Preliminary Remediation Goals." Accessed on April 14. On-Line Address: <http://www.epa.gov/region9/waste/sfund/prg/index.html>
- EPA. 2002b. "Maximum Contaminant Levels." Accessed on April 15. On-Line Address: <http://www.epa.gov/epa-water/2000/june/day-21/w9534.htm>
- EPA. 2002c. "National Recommended Water Quality by Criteria." Accessed on April 16. On-Line Address: <http://www.epa.gov/fedregstr/epa-water/1998/december-day-10/w30272.htm>

APPENDIX A
METHOD PRECISION AND ACCURACY GOALS

TABLE A-1

**VOLATILE ORGANIC COMPOUNDS
CONTRACT LABORATORY PROGRAM METHOD
PRECISION AND ACCURACY GOALS**

(Page 1 of 1)

Laboratory and Matrix Spike Limits

Fraction	Spike Compound	Water % Recovery	Soil % Recovery	Water RPD	Soil RPD
VOC	1,1-Dichloroethene	61 to 145	59 to 172	14	22
VOC	Trichlorethene	71 to 120	62 to 137	14	24
VOC	Chlorobenzene	75 to 130	60 to 133	13	21
VOC	Toluene	76 to 125	59 to 139	13	21
VOC	Benzene	76 to 127	66 to 142	11	21

Surrogate Recovery Limits

Fraction	Surrogate Compound	Water % Recovery	Soil % Recovery
VOC	Toluene-d ₈	88 to 110	84 to 138
VOC	Bromofluorobenzene	86 to 115	59 to 113
VOC	1,2-Dichloroethane-d ₄	76 to 114	70 to 121

Notes:

RPD Relative percent difference

VOC Volatile organic compound

TABLE A-3

**PESTICIDES AND POLYCHLORINATED BIPHENYLS
CONTRACT LABORATORY PROGRAM METHOD
PRECISION AND ACCURACY GOALS**

(Page 1 of 1)

Laboratory and Matrix Spike Limits

Fraction	Spike Compound	Water % Recovery	Soil % Recovery	Water RPD	Soil RPD
Pest/PCB	Gamma-BHC	56 to 123	46 to 127	15	50
Pest/PCB	Heptachlor	40 to 131	35 to 130	20	31
Pest/PCB	Aldrin	40 to 120	34 to 132	22	43
Pest/PCB	Dieldrin	52 to 126	31 to 134	18	38
Pest/PCB	Endrin	56 to 121	42 to 139	21	45
Pest/PCB	4,4'-DDT	38 to 127	23 to 135	27	50
Pest/PCB	Aroclor 1260	50 to 150	50 to 150	50	50

Surrogate Recovery Limits

Fraction	Surrogate Compound	Soil % Recovery	Water % Recovery
Pest/PCB	Tetrachloro-m-xylene	30 to 150	30 to 150
Pest/PCB	Decachlorobiphenyl	30 to 150	30 to 150

Notes:

BHC Benzene hexachloride
 DDT Dichlorodiphenyltrichloroethane
 PCB Polychlorinated biphenyl
 RPD Relative percent difference

TABLE A-5
INORGANIC ANALYSES
PRECISION AND ACCURACY GOALS
(Page 1 of 1)

Analyses	Method	% Recovery^a	Water RPD^b	Soil RPD^b
Metals	CLP SOW ^c	75 to 125	± 20	± 35
Mercury	EPA 1631C ^d	75 to 125	± 20	± 35

Notes:

CLP Contract Laboratory Program
RPD Relative percent difference
SOW Statement of work

- a Percent recovery control limit is based on spiked sample
- b Relative percent difference control limit is based on duplicate sample
- c U.S. Environmental Protection Agency (EPA) 2000a
- d EPA 2001

SOP APPROVAL FORM

TETRA TECH EM INC.

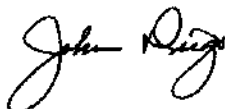
ENVIRONMENTAL STANDARD OPERATING PROCEDURE

USING THE GEOPROBE SYSTEM

SOP NO. 054

REVISION NO. 1

Last Reviewed: December 1999



Quality Assurance Approved

March 28, 1994

Date

1.0 BACKGROUND

This standard operating procedure (SOP) details all procedures for using the Geoprobe System, a hydraulically operated sampling probe, and its specialized sampling tools. The procedures described within this SOP include soil gas sampling, groundwater sampling, and soil sampling procedures as well as procedures for installing piezometers and vapor sampling implants. This SOP also describes general procedures for rod removal, backfilling, and decontamination which are common elements to all sampling procedures. This SOP No. 054 replaces former draft SOP No. 054 (Geoprobe Soil Gas Sampling) and draft SOP No. 055 (Geoprobe Groundwater Sampling).

Use of the Geoprobe System is only one of many sampling techniques used by Tetra Tech EM Inc. (Tetra Tech); however, it is a preferred sampling method when certain conditions prevail. Specifically, Geoprobe sampling should be considered when sampling is limited to relatively shallow depths and any of the following are factors: (1) costs must be kept very low, (2) the time period is short to perform the sampling, (3) maneuverability is important, and (4) the required sampling volume is limited.

Prior to the use of the Geoprobe equipment, all buried utility lines and other underground structures must be marked because this equipment can penetrate buried piping and tanks. A diagram of the Geoprobe system is shown in Figure 1.

1.1 PURPOSE

The purpose of SOP No. 054 is to establish positioning, preparing, and sampling procedures; piezometer and vapor sampling implant installation procedures; rod removal procedures; backfilling procedures; and decontamination procedures to guide field personnel.

1.2 SCOPE

The procedures outlined in SOP No. 054 are applicable to all Tetra Tech personnel involved in soil gas, soil, or groundwater sampling using the Geoprobe System or any of its specialized equipment. It also is applicable to all personnel using the Geoprobe System to install piezometers and vapor sampling implants. This SOP, in fact, applies to all uses of the Geoprobe System.

1.3 DEFINITIONS

Because Geoprobe Systems is a corporation specializing in an innovative sampling process, many of the terms used to describe its equipment are specialized and specific. For this reason, familiarity with hydraulic system, soil sampling, soil gas sampling, and groundwater sampling terms is necessary. These terms are discussed below.

1.3.1 Hydraulic System Terms

The following terms are principally used to discuss the basic operation of the hydraulic punch and its major components. If terms are encountered while using this SOP that are not listed below, check Sections 1.3.2, 1.3.3, and 1.3.4 below.

Hydraulic Punch: The principal part of the Geoprobe System, the hydraulic punch, looks very much like a small mobile drilling rig and is usually attached to a truck or van. The punch's hydraulic system uses the weight of the vehicle for support and a hydraulic system installed in the vehicle to advance sampling tools into the soil (see Figure 1).

Hammer: The hydraulic hammer pounds the rods and accessories into the soil once the hydraulic punch is unable to push it farther (see Figure 1).

Control Panel: The control panel is located near the hydraulic punch and contains the levers that control the movement of the punch (see Figure 2).

Probe Lever: This lever is found on the control panel and causes the hydraulic punch to push the drive rod and accessories into the soil. Overall, this lever controls the vertical movement of the punch (see Figure 2).

Hammer Lever: This lever is found on the control panel and engages the hydraulic hammer when the hammer release valve is moved to its extended position (see Figure 2).

Hammer Release Valve: This lever is found on the front of the hydraulic punch and allows the hammer to work when in its extended position. If the valve is not extended, pushing the hammer lever will not engage the hammer.

Foot Lever: This lever is found on the control panel and lowers the foot of the hydraulic punch so that it rests on the ground to stabilize the punch (see Figure 2).

Extend Lever: This lever is found on the control panel and controls the horizontal movement of the hydraulic punch. The lever extends the punch out of the van or truck. It also enables the hydraulic punch to extend about 2 feet from the rear of the vehicle (see Figure 2).

Fold Lever: This lever is found on the control panel and folds and unfolds the hydraulic punch so that it can be easily moved and stored (see Figure 2). This lever enables the hydraulic punch to move from the horizontal position to the vertical position.

Electrical Control Switch: This switch is found on the control panel and turns on the Geoprobe System's hydraulic system. None of the other levers work until this switch is turned on. It has slow, fast, and off speed positions (see Figure 2).

Vacuum System Panel: The vacuum system panel is located near the right rear of the vehicle and contains the vacuum system controls, the hydraulic oil cooling switch, and the remote ignition (see Figure 2).

Remote Ignition: This device is found on the vacuum system panel and allows one to start the vehicle's engine from near the hydraulic punch instead of walking around the vehicle and climbing into the vehicle's cab (see Figure 2).

Hydraulic Oil Cooling Switch: This switch is found on the vacuum system panel and turns on the auxiliary cooling system for the hydraulic oil (see Figure 2).

Vacuum/Volume (Vac/Vol) Pump Switch: This switch is found on the vacuum system panel and allows pressure to build up in the vacuum tank (see Figure 2).

Vacuum Line Valve: This valve is found on the vacuum system panel and opens and closes the vacuum line (see Figure 2).

Sample Line Gauge: This gauge is found on the vacuum system panel and registers the sample line pressure in inches of mercury (see Figure 2).

Drive Rod: The Geoprobe drive rod (sometimes called a probe rod) is a high-strength-steel, hollow tube with a 1-inch outer diameter. Though the rods come in 1-foot, 2-foot, and 3-foot lengths, the standard length is 3 feet. Each rod is threaded on both ends and has a male end and a female end (see Figure 3).

Drive Cap: This cap is a steel cap screwed onto the male end of the drive rod so that the rod can be pushed or hammered into the soil without damaging its threads. The drive cap is always installed to the top of the drive rod before advancing probe rods or sampling tools (see Figure 3).

Pull Cap: This cap is a steel cap that screws onto the male end of the drive rod and is used to pull the drive rod from the soil once the sample has been collected (see Figure 3).

Anvil: This piece of steel is placed inside the hydraulic punch at the point where the hammer actually makes contact. The anvil transfers the force of the hammer to the drive cap (see Figure 3).

Rotary-Impact Carbide-Tipped Drill Bit: This 18-inch or 24-inch steel drill bit fits directly into the hydraulic punch and is used to drill through concrete or hard asphalt. The bit does not spin with appreciable torque but is driven by the hammer, spinning only slightly to clear itself of debris (see Figure 3).

Chain-Assisted Pull Cap: This modified pull cap is attached to the hydraulic punch with a chain. It is most useful when the drive rod, for one reason or another, is not aligned directly underneath the hydraulic punch. With this cap, the rod can still be pulled using the punch (see Figure 3).

Rod Extractor: This tool threads onto a drive rod and is sent down into the hole made by a drive rod that has broken in the soil. The rod extractor, which looks a little like a drill bit, is then hammered into the broken rod and is used to pull the broken rod from the soil (see Figure 3).

Rod Pull Plate: This steel plate has a hole in its center through which a drive rod can be fitted. It is used to extract drive rods when installing piezometers, soil gas implants, or to expose the screen to groundwater when using a screen point sampler (see Figure 3).

O-Ring: An O-ring is a rubber ring used to seal sections of drive rods or various other Geoprobe tools so that, once together, they are air- and water-tight.

Teflon Tape: This inert, sticky tape can be used to create air-tight seals when pieces of the drive rod or accessories are threaded together. The tape can replace an O-ring.

1.3.2 Soil Sampling Terms

These terms are usually used when discussing soil sampling using the Geoprobe System. Sometimes, though, the terms are used when discussing other sampling techniques. If terms are encountered while using this SOP that are not listed below, check Sections 1.3.1 above and Sections 1.3.3 and 1.3.4 below.

Shelby Tube: This tube is used to collect large samples of cohesive soils. Its greatest disadvantages are that it cannot be used to sample from depths greater than about 10 feet and has no mechanism to stay closed until reaching the proper depth (see Figure 4).

Shelby-Tube-Drive Head: This 2-inch diameter piece of steel attaches to the Shelby tube using hex bolts. The Shelby-tube-drive head consists of two parts: a standard 2-inch Shelby tube drive head and a Geoprobe drive rod adapter. This allows the 2-inch wide Shelby tube to be driven by the hydraulic punch, which is actually designed for 1-inch diameter drive rods (see Figure 4).

Hex Bolts: These are the bolts used to attach a Shelby tube to a drive head (see Figure 4).

Extruder Latch: This device secures the Shelby tube to the extruder rack during the extrusion process that removes the soil from the tube (see Figure 4).

Extruder Piston: This piston is threaded onto a drive rod, and with the help of the hydraulic punch, extrudes the soil sample from the Shelby tube (see Figure 4).

Probe-Drive Systems: This sampling system allows samples to be collected at deeper depths than the Shelby tube system. Each probe-drive sampler remains closed until it reaches the depth desired and then is opened by those operating the punch by removing a stop pin (see Figure 5). The sampler is then pushed through the soil at the desired depth and removed. Three types of probe-drive samplers exist: the standard sampler, the Kansas sampler, and the large bore probe-drive sampler.

Standard Probe-Drive Sampler: This probe-drive sampler has a diameter of 1 inch and lengths of 10 or 24 inches. Its greatest difference from the other probe-drive sampler is that it does not have a removable cutting shoe (see Figure 5).

Stop Pin: This pin stops the point of a probe-drive sampler from retracting into the sampler tube. Once it is removed, the sample can be collected (see Figure 5).

Piston Rod: This rod connects the drive head of a probe-drive sampler to the sampler's point. Once the stop pin is removed, this rod slides through the sampler, allowing the point to retract inside the tube (see Figure 5).

Drive Head: This head is the top of a probe-drive sampler, which allows the piston rod to slide straight up the sample tube after the piston stop has been removed and the drive rod is advanced (see Figure 5).

Cutting Shoe: This portion of the probe-drive sampler cuts through the soil once the point is allowed to retract inside. The Kansas samplers and large-bore sampler have removable cutting shoes (see Figure 5).

Extruder Rack: This device holds soil samplers in place during extrusion. The Shelby tube extruder rack is shown in Figure 4, and the standard probe-drive extruder rack is shown in Figure 5.

Extension Rod: This long, thin, threaded, solid rod is dropped through a drive rod to the probe-drive sampler so that the stop pin can be removed. Often more than one extension rod (an extension rod string) must be put together to reach the stop pin (see Figure 5).

Extension Rod Handle: This small metal handle screws to the top of the extension rod string so that it can be turned easily while being used to remove the stop pin (see Figure 5).

Large-Bore Probe-Drive Sampler: This probe-drive sampler is 1-1/8 inches in diameter and 24 inches long. Its larger width allows for the collection of larger samples. The diameter also allows for acetate or brass liners to be used in sample collection. These liners can make viewing the sample easier and preparing it for analysis simpler.

Kansas Sampler: This specially designed probe-drive sampler has a removable cutting shoe to enable easy extraction of soil and to allow the shoe to be replaced without replacing the complete sampler.

Kansas Stainless Sampler: This sampler has a stainless-steel sampling tube. It works in the same way as the Kansas sampler.

1.3.3 Soil Gas Sampling Terms

The following terms are used principally to discuss soil gas sampling. A few terms, though, are used while discussing groundwater sampling as well. If unfamiliar terms not listed below are encountered while using this SOP, check Sections 1.3.1 and 1.3.2 above and Section 1.3.4 below.

Expendable Point: These points fit into an expendable point holder that has been threaded into the lead drive rod. When the drive rod is pulled back, these points do not move with it, leaving a gap from which soil gas can be collected. The points are ultimately left in the ground (see Figure 6).

Expendable Point Holder: This holder threads into the leading drive rod. It is used for driving expendable points (see Figure 6).

Retractable Point Holder: This holder lifts off its point, leaving a gap so that soil gas can be drawn, but unlike expendable points, the holder does not separate completely and ultimately is retrieved with the lead drive rod (see Figure 6).

Gas Sampling Cap: When using the standard soil gas sampling method, the gas sampling cap replaces the drive cap on top of the drive rod and allows tubing to be connected to the drive rod. A soil gas sample is drawn through the probe rod through this cap and into a sample container (see Figure 6).

Post-Run Tubing (PRT) System: This system collects soil gas drawn directly through a tube instead of through the drive rod itself. The system involves one of two specially designed point holders, each threaded on top so that an adapter that has been attached to the tube can be screwed into it after being advanced down the drive rod string. The two point holders differ in that one uses a retractable point and the other uses an expendable point (see Figure 7).

PRT Expendable Point Holder: This holder is threaded into the leading probe rod and is used for driving expendable points (see Figure 7).

PRT Adapter: The PRT adapter attaches the tubing through which the soil gas is to be drawn to the point holder, which has been driven to the proper sampling depth (see Figure 7).

Polyethylene Tubing: This tubing is the preferred tubing for connecting the PRT system to the sample container. Its stiff nature, however, sometimes makes it difficult to attach to the sample container and a coupler of Tygon tubing is necessary (see Figure 7).

Tygon Tubing: This tubing is the preferred tubing for connecting soil gas sampling containers to the drive rod and vacuum system. It often is also necessary as a coupler sample between the stiff polyethylene tubing used with PRT sampling systems and the sample container.

Glass Bulb: This bulb of glass has valves on each side and a neoprene septum through which gas can be withdrawn. The bulb is used to collect soil gas and can be used as the container in which the gas is taken for analysis (see Figure 8).

Tedlar Bag: This small bag has a valve on it. It is placed in an air-tight chamber, the air in the chamber is evacuated, and the bag fills with soil gas. The bags can then be taken for analysis.

Tedlar Bag Chamber: Tetra Tech uses these modified, air-tight kitchen containers as vacuum chambers. These chambers are modified with nipples on each side, which enable it to be attached to a vacuum pump, to a Tedlar bag, and to the Tygon tubing.

1.3.4 Groundwater Sampling Terms

The following terms are used to discuss groundwater sampling. If unfamiliar terms not listed below are encountered while using this SOP, check Sections 1.3.1, 1.3.2, and 1.3.3 above.

Mill-Slotted Well Point: This 3-foot long tube has 15 mill-cut slots in it, each 2 inches long and 0.020 inches wide. Only the bottom 2 feet of this tube is slotted, and sometimes mill-slotted well points come in two parts: a 2-foot slotted section and a 1-foot unslotted section. The slots allow groundwater to enter (see Figure 9).

Geoprobe Screen Point Sampler: This sampler has a 19-inch screen that encases a perforated stainless-steel sleeve. Once in place, the screen allows the water to enter the tube and prevents coarse sediment from entering the tube (see Figure 9).

Thieving Tube: This tube is used to extract the water from either mill-slotted well points or Geoprobe screen point samplers, Tetra Tech uses polyethylene tubing as thieving tubes. This tubing is lowered into the water, capped on top, and then extracted. The result is much like putting a straw into a glass of water, sealing the straw with a finger and lifting it. This method is used primarily for the collection of groundwater samples to be analyzed for volatile organic compounds. A check valve can also be attached to the thieving tube which seals the bottom and holds the groundwater within the tube.

Check Valve: This stainless steel valve has a small ball which, when attached to a thieving tube, floats to the top of the groundwater table and then sinks, ultimately sealing the thieving tube with groundwater. Oscillating the thieving tube will allow groundwater to rise within the tube for larger retrieval volume.

Well Mini-Bailer: This specially designed bailer drops through the drive rods and into the groundwater in the mill-slotted well point or screen point. A small ball in the bailer floats to the top and then sinks, ultimately sealing the bailer after it fills with about 40 milliliters of groundwater.

1.4 REFERENCES

The following references were used to prepare this SOP:

- Driscoll, F.G. 1987. *Groundwater and Wells*. Second Edition. Johnson Division. St. Paul, Minnesota.
- Fisher Scientific. 1991. "The Fisher Catalog of Scientific Instruments."
- Geoprobe Systems. 1990. "8-M Operations Manual." July 27.
- Geoprobe Systems. 1991. "Accessory Tools Catalog."
- Geoprobe Systems. 1992. "Equipment and Tools Catalog."

2.0 POSITIONING, PREPARING AND SAMPLING PROCEDURES

The Geoprobe System uses a hydraulic punch that is usually installed in the back of a van or truck to first push and then to hammer its hollow drive rod through soils. Depending on which tools are attached to the end of the drive rod and which sampling equipment is attached to it, the Geoprobe can be used to remove soil, soil gas, or groundwater. It can also be used to drill through cement or concrete and can aid in the installation of piezometer wells and vapor sampling implants. The following sections detail the procedures for positioning the Geoprobe unit, preparing the sampling system, and sampling with the Geoprobe unit.

2.1 POSITIONING THE GEOPROBE UNIT

Before the Geoprobe System can be used, the Geoprobe hydraulic punch and accessories must be properly positioned near the sampling site. The hydraulic punch and other equipment also needs to be prepared. In cases where concrete or other hard surfaces hinder sampling, the Geoprobe must be used to reach soil.

This section details methods to perform these activities.

To position and unload the Geoprobe System use the following procedures:

1. Drive the vehicle containing the Geoprobe System to the sampling location and align the center of the rear of the vehicle with the point at which the sample will be taken. The rear

bumper should be 1 to 2 feet from the sampling point so that the foot of the hydraulic punch can be extended out over it.

2. Shut off the vehicle.
3. Put it in park.
4. Set the emergency brake before proceeding.
5. One person only should operate the hydraulic punch and the assembly and disassembly of probe rods and accessories. A second person is usually necessary to handle the samples and to decontaminate equipment. All personnel present must wear steel-toed shoes, gloves, and eye protection. When drilling through concrete or using the hydraulic hammer, ear protection is also necessary.
6. Once ready to take the sample, start the engine using the remote ignition located in the right rear of the vehicle. As a safety device, the remote ignition will not work unless the vehicle is in park.
7. Activate the hydraulic system by turning on the electrical control switch. The vehicle's engine must be running for the hydraulic system to work.
8. Slowly extend the Geoprobe out of the vehicle using the extend lever. Always use the slow speed on the hydraulic controls when positioning the hydraulic punch. The punch and mast should be far enough out of the van or truck so that the mast will not strike the roof when it is unfolded.
9. Unfold the hydraulic punch out of the vehicle using the fold lever. Once the punch has been lined up perpendicular to the ground surface, lower the foot of the punch using the foot lever until the vehicle itself is raised about 1 foot on its springs. This stabilizes the vehicle and punch. **Never lift the vehicle completely off the ground using the foot lever.** Doing so destabilizes the vehicle and hydraulic punch and may cause damage to equipment or injury to those nearby. Also, as pressure is placed on the rod, tools, and accessories, the foot of the punch may begin to lift. Do not allow it to lift farther than 6 inches from the ground. Allowing it to lift farther than 6 inches may throw the vehicle off balance and cause the rod to bend or break.

The Geoprobe System is now positioned. If it is necessary to drill through concrete or hard asphalt, use the following procedures:

1. Raise the hydraulic punch using the probe lever and then deactivate the hydraulic system by turning the electrical control switch to off. The hydraulic system should always be turned off when the hydraulic controls are not being used.
2. Place the drill bit into the hydraulic hammer. The bit is not used with a drive rod or anvil.

3. Activate the hammer rotation control knob, which is located on the hydraulic hammer, by turning the knob counter-clockwise. This allows the drill bit to rotate when the hammer lever on the control panel is pressed.
4. Activate the hammer release valve, which is located on the hydraulic hammer, by pulling the lever out and down.
5. To drill through solid surfaces, both the probe and hammer mechanisms of the hydraulic punch must be used. The hammer mechanism drives the drill bit in a percussion fashion and causes it to turn slightly. The probe mechanism allows the hammer and bit to be raised and lowered so that the bit can clear itself of debris. Once ready to begin, turn on the hydraulic system.
6. Fully depress the hammer lever. This lever needs to remain depressed throughout the drilling procedure and keeps the bit pounding and rotating.
7. Put pressure on the bit by pressing the probe lever down. Using this lever, advance the bit in small increments through the concrete or other hard surface. If advanced too quickly, the bit will bind and stop rotating. Should this happen, raise the punch slightly to allow the bit to rotate. If too little pressure is placed on the bit, too little percussion will occur, and drilling will be slow.
8. Continue drilling, in small increments, until soil has been reached. At that time prepare for sampling.

2.2

PREPARING THE SAMPLING SYSTEM

Before the hydraulic punch is used to sample, decisions must be made concerning which type of sample will be taken, whether several samples will be taken at varying depths, and which type of Geoprobe sampling equipment will be used. The following sections discuss preparation procedures for soil sampling, soil gas sampling, and groundwater sampling.

2.2.1

Soil Sampling

The samplers attached to the hydraulic punch for soil sampling come in two forms. The first type is the 2-inch diameter Shelby tube system that is common to other soil sampling methods. The second system uses various specially designed probe-drive systems that remain completely sealed while being pushed or driven to a particular depth. They then are opened to allow a sample to be collected. The Shelby tube and probe-drive systems are discussed below.

Shelby Tube System

The Shelby tube is a thin-walled steel tube, 2 inches in diameter and 30 inches long, with four mounting holes around its top. It allows large amounts of soil to be sampled at once, but the soil must be relatively cohesive. Because the tube remains open at all times, the tube cannot be driven to great depths and must be removed and replaced after coring 30 inches of soil. Usually, the Shelby tube system is chosen when large amounts of soil are needed at depths no deeper than 10 feet. Rocky or sandy soils are not conducive to this sampling method.

To prepare for sampling using Shelby tubes, use the following procedures:

1. First attach a Shelby tube to the Shelby-tube-drive head by putting the head's hex bolts through the holes in the tube.
2. Next, screw a Geoprobe drive rod adapter into the top of the drive head to allow the 2-inch-wide Shelby tube to be driven by the hydraulic punch and hammer, which are actually made for 1-inch outer diameter drive rods.
3. A drive cap is then screwed onto the top of Geoprobe drive rod adapter. The tube is now ready to be attached to the hydraulic punch.
4. To attach the tube, raise the hydraulic punch using the probe lever and then turn off the Geoprobe hydraulic system.
5. Lift the hammer latch and insert the anvil inside.
6. Place the assembled Shelby tube sampler so that it is aligned under the anvil.

The hydraulic punch is now ready to drive a Shelby tube and collect a sample core. For collecting soil cores at depths of greater than 30 inches, attach sections of probe rod to an assembled Shelby tube sampler and drive the sampler down the same hole using a new Shelby tube for each 30-inch increment in depth.

Probe-Drive Systems

All of the probe-drive systems work in essentially the same way. A sampler is attached to a hollow drive rod, inserted into the hydraulic punch, and punched or hammered into the soil. Once the sampler reaches the depth at which the sample is to be taken, a stop pin in the sampler is removed using an extension rod

that has been dropped through the inside of the hollow drive rod. The release of the stop pin allows the point of the sampler to retract inside the sample tube as the sampler is further advanced into the soil. The probe is then punched through the soil where the sample is to be taken. The rod and probe are then pulled to the surface for sample extraction.

Currently, three types of samplers are used in the probe-drive systems: the standard probe-drive sampler, the Kansas sampler, and the large bore probe-drive sampler. Preparation of each is slightly different. Each is discussed separately below.

Standard Probe-Drive Samplers

The standard probe-drive sampler comes in 10- and 24-inch lengths. The proper length is determined by the size of the sample desired. The point of this sampler is connected to a piston rod that will slide through its length. At its top, the piston rod is connected to the drive head, which keeps it centered and holds the piston stop pin, which stops the piston from sliding.

To prepare the standard probe-drive sampler, use the following procedures:

1. Insure that the sampler is assembled and complete, and that the piston stop pin which is reverse threaded is tightly locked so that the sampler point will not slide into the sampling tube.
2. Attach a shortened Geoprobe drive rod to the sampler so that the total length is nearly the standard 3 feet. If the 10-inch sampler is used, a 2-foot drive rod should be attached, and if the 24-inch sampler is used, a 1-foot drive rod should be attached.
3. Screw a drive cap onto the top of the shortened drive rod. The sampler is now ready for attachment to the hydraulic punch.
4. To insert the probe-drive sampler, raise the hydraulic punch using the probe lever, and then turn the hydraulic system off.
5. Lift the hammer latch and insert the anvil inside.
6. Place the assembled standard probe-drive sampler and shortened drive rod directly under the anvil so that the drive cap touches the anvil and the point of the sampler is aimed at the place where the sample is to be taken. The standard probe-drive sampler and the hydraulic punch should both be vertical.

Kansas Samplers

The Kansas sampler is much like the standard probe-drive sampler. However, it has a removable hardened cutting shoe near its point that allows it to penetrate rockier soils and to be easily replaced and decontaminated. Kansas samplers come in two versions: the Kansas Stainless Sampler, which has a stainless-steel tube, and the Kansas Sampler, which has an alloy steel tube.

To prepare a Kansas sampler, use the following procedures:

1. Ensure that the hardened cutting shoe is in place.
2. Assemble and install the Kansas sampler in the same manner as the standard probe-drive sampler (see Procedures 2 through 7 above).

Large Bore Samplers

The large bore sampler, similar to both types of Kansas samplers, has a removable cutting shoe and works in the same manner. It is slightly larger than the Kansas samplers, usually 24 inches long and 1-1/8 inches wide. The larger bore allows for the use of acetate or brass liners. The soil, therefore, can be removed easily by removing the liner. The acetate liner allows for easy visual examination of the core and can be easily sliced away so that the sample can be prepared for the laboratory. The brass liners come in four 6-inch sections that allow for easy separation and packaging of 6-inch soil samples. Some laboratories accept full 6-inch brass liners, allowing the samples to be collected with a very minimal disturbance to the soil matrix.

To prepare a large-bore sampler, use the following procedures:

1. Place the desired liner into the sampler by unscrewing the cutting shoe and sampler drive head from the two ends and then inserting the liner.
2. Assemble the sampler and attach a 12-inch drive rod to the sampler.
3. Screw a drive cap onto the top of the drive rod.

4. Place the assembled sampler and drive rod under the hydraulic punch in the manner detailed in the section above for preparing standard probe-drive samplers (see Procedures 5, 6, and 7 above).

2.2.2 Soil Gas Sampling

Two main methods are used to collect soil gas using the Geoprobe system: the standard method and the PRT system.

To use the standard method, the drive rods are decontaminated and assembled in an air-tight manner as they are punched into the soil. To ensure an air-tight seal, either Teflon tape or an O-ring can be placed on the male threads of the drive rods. The probe rods are driven approximately 6 inches below the area from where the sample is to be taken. The rods are then lifted approximately 6 inches leaving the expendable point and a small opening between the point and the end of the rod behind. A gas sampling cap is then attached to the top of the rod, a vacuum pump removes the necessary volume of gas, and the sample is collected.

To collect soil gas samples using the PRT system, polyethylene tubing attached to a stainless steel adapter is pushed through the drive rod after the rod is in place. The tubing and adapter is then reverse threaded onto the top of the PRT expendable point holder, and the gas is collected through the tubing. This method increases the accuracy of soil gas sampling, eliminates the potential for leaks in the rod, and simplifies probe rod decontamination.

Standard Method

Only decontaminated drive rods can be used with the standard method. Rods should be decontaminated using the procedures in Section 6.0 of this SOP.

To prepare a decontaminated drive rod for soil gas sampling using the standard method, use the following procedures:

1. Screw an expendable point holder into the female end of a 3-foot drive rod. (Note: a retractable point can also be used with this method; however, decontamination requirements almost always preclude its use.)
2. Place an expendable point into this holder.
3. Screw a drive cap onto the male end of the drive rod.
4. Place the rod into the hydraulic punch.
5. Turn on the hydraulic system.
6. Install the anvil within the hydraulic punch's hammer by lifting the hammer latch and inserting it.
7. Place the assembled drive rod directly under the anvil so that the drive cap faces the anvil and the expendable point is aimed at the desired sampling location.
8. Push sampler and hydraulic punch through the soil to gather the sample.

PRT System

Two types of PRT systems are available. The first uses an expendable point holder and expendable point like the standard method. The second uses a retractable point holder that lifts off of the drive-point without actually separating from it. Both systems allow the threading of a PRT adapter and tubing through the drive rod so that the gas can be taken from the depth required without being sucked through the drive rod.

To prepare the drive rod and sampler for PRT soil gas sampling, use the following procedures:

1. Select the desired PRT sampler (either one with an expendable point or one with a retractable point) and ensure that the PRT adapter easily screws into the threads on top of the sampler. This step is necessary to ensure that the adapter will fit easily when it is affixed from above ground.
2. If using the sampler with an expendable point, attach the point.
3. Screw the sampler to the end of a shortened drive rod so that the total length of the sampler is nearly 3 feet.
4. Screw the drive cap to the other end of the drive rod.

5. Attach the drive rod and sampler to the hydraulic punch using the same procedures detailed in the standard method (see Procedures 4, 5, and 6 above).

2.2.3 Groundwater Sampling

The Geoprobe System offers two systems for collecting groundwater, each with several groundwater sampling options. The first method involves the use of a mill-slotted well point. The second method uses a specially designed Geoprobe screen point sampler.

Mill-Slotted Well Points

The mill-slotted well point is a 2- or 3-foot length of hollow steel tubing with 15-milcut slots in it, each 2 inches long and 0.020 inches wide. Once in place, groundwater enters the tube through these slots. To prepare the mill-slotted well point, use the following procedures:

1. Screw a solid drive point into the female end of the sampler.
2. If a 2-foot well point is being used, screw the sampler to a 1-foot length of drive rod.
3. Screw a drive cap to the other end of the well point or 1-foot drive rod.
4. Place the sampler and rod into the hydraulic punch by raising the punch as much as necessary and turn hydraulic system off.
5. Install the anvil within the hydraulic punch's hammer by lifting the hammer latch and inserting it.
6. Place the mill-slotted well point sampler under the anvil with the drive cap near the anvil and the point aimed at the sampling location.

Geoprobe Screen Point Sampler

The Geoprobe screen point sampler has a 19-inch screen encased in a perforated stainless-steel sleeve. The screen remains encased in the sleeve until the screen point sampler reaches the desired depth. The rod is then pulled back approximately 19 inches, leaving the screen exposed to the formation. Flexible tubing can be pushed through the drive rod and attached to the sampler using the adapters for the PRT soil gas system, enabling groundwater to be removed without touching the drive rod. Decontaminating the drive rod is subsequently easier.

To prepare a Geoprobe screen point sampler, use the following procedures:

1. Close the screen on the sampler.
2. Attach its expendable point.
3. Attach the sampler to a shortened drive rod so that the assembly is nearly 30 inches long.
4. Place the sampler into the hydraulic punch using the methods detailed for mill-slotted well points (see Procedures 4, 5, and 6 above).

2.3 SAMPLING

Sampling procedures for the Geoprobe hydraulic punch are similar for all samplers and sampling media. This section presents general procedures that apply to all samplers and sample types, and specific operating procedures for soil, soil gas, and groundwater.

2.3.1 General Procedures

All control panel switches have a slow and fast position. All switches should initially be set at the slow position when positioning the punch and the sampling tools. In all cases, the hydraulic system should be shut off when not in operation and when adapters and additional drive rods are put into place. The hydraulic punch should be turned off any time it is not actually in operation.

The Geoprobe hydraulic punch is designed with a key safety feature that will shut it off if the controls are released. If the operator senses that something is wrong, he or she must release the controls and stop operating the punch until all is well. At no time should the foot of the punch be allowed to lift higher than 6 inches off the ground because the punch will destabilize and may bend the drive rod or sampling tube.

Also, at no time should part of a human body be placed on top of a drive cap while the cap is near the anvil or under the foot of the hydraulic punch.

Once the assembled sampler or drive rod is under the anvil, both it and the hydraulic punch should be vertical. Positioning the drive rod and sampler is critical in order to drive the rod vertically. Not positioning the sampler or drive rod vertically will result in problems when attaching subsequent drive rods needed to reach the proper depth and with rod retrieval.

To begin probing in soils of normal texture, use the following procedures:

1. Activate the hydraulic punch and push down on the probe lever on the control panel so that the probe slowly lowers itself. Always use the slow control on the first rod or sampler.
2. Continue to press on the probe lever until the rod or sampler is completely forced into the soil. The point of the rod will then be nearly 3 feet into the soil.

Soils and other materials are often too hard for the hydraulic punch's probe mechanism to penetrate. When this occurs, the hammer on the hydraulic punch should be used in accordance with the following procedures:

1. Ensure that the hammer rotation valve is closed.
2. Use the hydraulic punch to put pressure on the rod, sampler, and soil. When the probe rod refuses to move, the foot of the hydraulic punch will begin lifting off the ground. Never allow the foot to lift more than 6 inches off the ground, but never use the hammer with the foot resting on the ground surface.
3. If the probe foot lifts off the ground, the hydraulic punch may no longer be perpendicular. If this occurs, use the machine's fold lever, which is located on the control panel, to correct the punch's position.
4. Press the hammer lever on the control panel. The rod should now advance. Never use the hammer unless there is downward pressure on the drive cap because doing so may damage the equipment.
5. Stop hammering periodically and check to see if the probe rods can be advanced using the probe mechanism only.

When samples are to be taken at depths of greater than 3 feet, additional drive rods must be added to those already in the ground. Shelby tube soil sampling procedures for adding rods are discussed in Section

2.3.2. For all other sampling methods, use the following procedures to add drive rods:

1. Using the probe lever, raise the hydraulic punch off the portion of the drive rod protruding from the ground.
2. Unscrew the drive cap from the drive rod.
3. If using the standard method of collecting soil gas or other sampling methods that will draw the sample through the length of the entire drive rod, wrap the threads of the drive rod with Teflon tape or push an O-ring over the threads to make the drive rod string air- and water-tight.
4. Screw another drive rod onto the first drive rod protruding from the ground. Tighten the rods together with a pipe wrench.
5. Screw a drive cap onto the top of the new drive rod.
6. Place the hydraulic punch over the new drive rod and push the rod farther into the ground.

As the rod string is pushed farther into the ground, it will sometimes begin to loosen. The rods should remain tight so that the threads are not damaged. Occasionally, stop probing and twist the rod string with a pipe wrench to ensure that all of the joints remain tightly sealed.

2.3.2 Soil Sampling

This section presents procedures used to sample soils using either the Shelby tube sampling method or any of the probe-drive systems. In all cases, sampling tools should never be advanced farther than their length once they are opened because the sampler will overfill. If the sampler overfills, it could be damaged or expand, causing it to fall off the drive head.

Shelby Tube Sampling Procedures

Because the Shelby tube does not remain closed until it reaches the desired sampling depth and because it is not connected to a drive rod but to a Shelby drive head, sampling procedures for Shelby tubes differ greatly from soil sampling with other methods. New drive rods cannot be continuously added. Sampling at depths of greater than 30 inches requires a step-like procedure. For example, to sample to a depth of 90 inches, three Shelby tubes are needed. The first is advanced from 0 to 30 inches and then removed. The second is pushed through the hole made by the first and advanced to a depth of 60 inches and removed. The third is also pushed through the 60-inch deep hole and advanced from 60 to 90 inches.

Samplers must be ready to change sampling methods if necessary. For example, if soils are not cohesive, they tend to drop out of the Shelby tube as it is pulled from the ground. Also, if the soils are not cohesive, they tend to collapse into the hole left by the initial tube before the second and third tubes can be pushed into place. For this reason, use of the Shelby tube method is impractical at depths of greater than 10 feet. Rocky soils are also difficult to sample with a Shelby tube sampler because they tend to destroy the sampler while it is being driven into the ground.

To sample using the Shelby tube method, use the following procedures:

1. Turn on the hydraulic system and slowly press the Shelby tube into the soil using the probe lever on the control panel.

2. Once the tube has reached the sampling depth or has been extended to nearly its full 30-inch length, stop the hydraulic punch and raise it off the drive cap and Shelby tube drive head.
3. Unscrew the drive cap.
4. Screw on a pull cap.
5. Lower the hydraulic punch and lift the hammer latch. Remove the anvil. Place the latch around the pull cap so that the latch will hold the cap to the hydraulic hammer.
6. Using the probe lever, raise the hydraulic punch to pull the Shelby tube from the ground.

If the desired sampling depth is greater than 30 inches, additional Shelby tubes and probe rods must be used. The tubes are then prepared for probing using the methods presented in Sections 2.2.1 and 2.3.1 above. To advance the Shelby tube deeper, the tubes are pushed through the hole left by the first tube using the method detailed above.

Once a Shelby tube core has been retrieved from a sampling point, it must be extruded from the Shelby tube sampler using the following procedures:

1. Lower the hydraulic punch using the probe lever so that its mast will not strike the top of the van as it is folded.
2. Lift the foot of the hydraulic punch using the foot lever.
3. Slowly and carefully fold the hydraulic punch using the fold lever.
4. Once the punch is horizontal, the Shelby tube extruder bracket can be placed onto the punch's foot. This bracket will hold the Shelby tube in place and allow the punch to push the soil out of the tube.
5. Screw an extruder piston onto a drive rod and a drive cap on the drive rod's other end.
6. Place the drive rod into place under the horizontal drive punch.
7. Place the full Shelby tube into the extruder rack and secure it with the extruder latch.
8. A pan or container should be held at the end of the Shelby tube to collect sample material as it is extruded.
9. The probe lever activates the hydraulic punch and pushes the soil from the Shelby tube.

Tetra Tech's SOPs on packaging and documenting samples, SOPs Nos. 016, 017, 018, and 019, should be used to prepare the sample for analysis.

Probe-Drive System Sampling Procedures

All three types of probe-drive samplers work in essentially the same way. The sampler is advanced to just before the proper sampling depth and then the drive point is released by removing a stop pin using solid extension rods that have been dropped through the hollow drive rod. The point is then pushed back into the body of the sampler as the sampler fills with the soil sample.

In addition to the general procedures listed in the Section 2.3.1, the probe must be stopped at just before the desired sampling depth so that the stop pin can be removed. Pushing the probe too far will require starting over.

To use the probe-drive sampling system to sample soil, use the following procedures:

1. Attach additional drive rods as discussed in the general procedures in Section 2.3.1.
2. Stop the hydraulic probe just before the desired sampling depth.
3. Raise the hydraulic punch, turn off the hydraulic system, and remove the drive cap.
4. Insert an extension rod into the drive rod and screw additional extension rods together until the assembly reaches the same depth as the sampler.
5. Attach a small extension rod handle to the top of the extension rod.
6. Rotate the extension rod handle clockwise until the leading extension rod has turned the stop pin and disengaged it.
7. Pull and unscrew each extension rod from the hollow drive rod. The stop pin should be attached to the bottom of the extension rod string. If not, repeat Procedures 1 through 6.
8. To sample, mark the drive rod with tape or chalk about 10 inches above the ground if a 10-inch sampler is used or 24 inches from the ground if a 24-inch sampler is used.
9. Replace the drive cap and start the hydraulic system.

10. Drive the rod until the tape or chalk mark touches the ground. Be careful not to overdrive the sampler. Doing so could compact the soil in the sampler or cause it to balloon outward, making soil removal and extrusion difficult.
11. Raise the hydraulic punch and replace the drive cap with the pull cap. Remove the anvil.
12. Latch the pull cap underneath the hydraulic hammer latch and pull the rods out of the ground, disassembling the rod as needed.
13. Check to ensure that a soil sample is now in the sampler.

Once a soil sample has been removed from the ground, it can be extruded using the Geoprobe. The tools supplied by Geoprobe Systems for extruding soil from probe-drive samplers do not require the Geoprobe to be folded and horizontal. If liners are used with large-bore samplers, extrusion is usually unnecessary. When extrusion is necessary for probe-drive samplers, use the following procedures:

1. Raise the foot of the hydraulic punch off the ground using the foot lever on the control panel.
2. Attach the extruder rack onto the foot of the punch so that its crossbeam rests on top of it.
3. Completely disassemble the sampler. In all cases, remove the piston, point, and drive head of the sampler. If using the Kansas and large-bore samplers, unscrew the removable cutting shoe as well.
4. Insert the sample tube into the extruder with its cutting end up.
5. Insert a disposable wooden dowel or the reusable steel piston above the soil and below the hydraulic punch so that pressure on the dowel or piston from the punch will push the soil out of the bottom of the sample tube.
6. Position proper sampling jars or trays under the sample tube and very slowly use the probe lever to force the soil out of the tube. Injury can result if the soil is quickly forced from the tube.

The soil sample is now ready for packaging or on-site laboratory analysis. For large-bore samplers, the soil may be contained in a plastic sleeve that can be sliced away once the soil is to be packaged or in a brass sleeve that may be capped on both ends and shipped to the laboratory as is. Tetra Tech's SOPs on packaging and documenting samples for analysis should be followed when collecting samples using the Geoprobe System.

2.3.3 Soil Gas Sampling Procedures

The standard method and the PRT system are used for collecting soil gas using the Geoprobe System. The standard method requires the drive rods to be sealed together with either O-rings or Teflon tape to ensure an air-tight seal so that soil gas from depths other than the bottom of the drive-rod string cannot penetrate the system.

The PRT system draws soil gas through continuous tubing that is dropped through the drive rod after the drive rod has reached the desired level. The tubing is then attached directly to the point holder at the end of the drive-rod string.

For both methods, the drive rod should be driven to the desired depth. The drive cap should be replaced by the drive pull cap, and the rod should be pulled back out of the hole approximately 6 inches. This 6-inch void is the area where the soil gas sample is collected from. A pipe wrench or vise-grip pliers should be attached to the pipe just above the foot of the hydraulic punch so that the wrench or pliers rests on the foot to stop the drive rod from working its way back down into the hole.

Tygon tubing should be replaced between each sample for both sampling methods to avoid cross contamination.

The standard method and the PRT system sampling procedures are presented below. In addition, procedures for collecting soil gas in Tedlar bags, glass bulbs, and adsorption tubes is also presented below.

Standard Method

To gather a sample using the standard method, raise the hydraulic punch as mentioned above and replace the drive cap with a gas sampling cap. This cap is designed to fit the drive rods and is used to connect them by tube to a vacuum supply. Once the tubing has connected the gas sampling cap to the vacuum supply, remove the volume of air necessary to ensure that none of the gas being drawn was in the rod during probing, and then collect the sample in either Tedlar bags, glass bulbs, or adsorption tubes as discussed below.

PRT System

To use the PRT system (with either an expendable or a retractable point) to collect soil gas samples use the following procedures:

1. Secure the PRT adapter to the end of a piece of polyethylene tubing 1 to 2 feet longer than the total length of the drive-rod string. The adapter must fit tightly within the tubing. If it does not, tape it into place. Also, ensure that the O-ring is in place on the threaded end of the adapter.
2. Remove the drive cap from the probing rod and lower the adapter into it, holding on to the tubing.
3. Grasp the excess tubing and apply downward pressure. Turn the tubing counter-clockwise to engage the adapter threads on the sampler holder.
4. Pull up lightly on the tubing to test engagement of threads. If the adapter has not engaged, try again. If it repeatedly does not engage, soil may have intruded into the drive rod either during probing or, in the case of the retractable point, when the rod was pulled back to leave the point opening. Use the threaded extrusion rods to clean out the threads.
5. In most cases, the adapter will easily screw into place. The sampler is now ready to collect samples in either Tedlar bags, glass bulbs, or adsorption tubes using the procedures presented below. After the sample is collected and the sampler and tube is removed from the ground, the O-ring should be checked to ensure that a good seal exists between the sampler and adapter. If the O-ring is tightly smashed, the seal should be good.
6. Discard polyethylene tubing and use new polyethylene tubing for each sample.

Tedlar Bags

Soil gas can be collected for chemical analysis in a 500-cubic-centimeter Tedlar gas sampling bag by inducing a vacuum on the exterior of the bag. The following procedures should be used to collect soil gas samples in Tedlar bags:

1. For the PRT system, connect a short (6- to 12-inch) piece of Tygon tubing to the free end of the polyethylene tubing protruding out of the drive rod. For the standard method, connect the Tygon tubing to the soil gas sampling cap.

2. Attach the other end of the Tygon tubing to one end of the Tedlar bag chamber. Tetra Tech uses modified, plastic, air-tight kitchen containers for these chambers. They are inexpensive and work well.
3. Connect another piece of Tygon tubing 2 feet to 3 feet long to the other end of the Tedlar bag chamber and to the nipple on the bottom of the vacuum system panel.
4. Place the lid on the Tedlar bag chamber.
5. Turn the vacuum/volume (vac/vol) pump switch on and allow pressure to build in the vacuum tank. Make sure that the vacuum line valve is closed before turning on the pump switch.
6. Open the vacuum line valve and purge three times the volume of ambient air out of the Tedlar bag chamber and PRT tubing or probe rods. The equations for determining purge volumes are as follows:

Probe rods or tubing

$$V = \pi r^2 H$$

where

V = Volume

$\pi = 3.14159$

r = Radius of tube or rod

H = Length of tube or rod

Vacuum chamber

$$V = LWH$$

where

V = Volume

L = Length of chamber

W = Width of chamber

H = Height of chamber

7. Close the line valve.
8. Clamp the Tygon tubing shut with hemostats.
9. Remove the lid from the Tedlar bag chamber.
10. Connect a Tedlar gas sampling bag to the fitting inside the Tedlar bag chamber and open the valve on the gas sampling bag.
11. Place the lid back on the Tedlar bag chamber, seal it tightly, and remove the hemostats.
12. Turn the vac/vol pump switch on and open the vacuum line valve to create a vacuum in the chamber. The Tedlar bag should fill once the vacuum is created. The rate at which

the Tedlar gas sampling bag fills depends on the permeability of the soil. The minimum amount of soil gas needed for analysis is approximately 0.5 liter. If less than 0.5 liter is collected after 4 minutes of sampling, raise the soil gas probe 0.5 foot and continue to evacuate the vacuum chamber for another minute. If the minimum required volume of soil gas is not collected, repeat the procedure. If the minimum required volume of soil gas is still not collected, abandon the collection process. All steps conducted should be accurately recorded in the logbook even if no samples are satisfactorily collected.

13. After the soil gas sample is collected in the Tedlar bag, clamp the Tygon tubing with hemostats.
14. Turn off the vacuum pump.
15. Remove the vacuum chamber lid.
16. Close the valve on the Tedlar gas sampling bag and remove the bag from the chamber. Label the Tedlar bag with the appropriate information.

Glass Bulbs

The following procedures should be used to collect soil gas in glass bulbs:

1. Turn the vac/vol pump switch on and allow pressure to build in the vacuum tank. Make sure that the vacuum line valve is closed before starting the vacuum pump. The inside scale of the vacuum tank gauge is calibrated in inches of mercury. The outside scale is calibrated for volume in liters (at standard temperature and pressure). Obtain the desired vacuum and turn the vacuum pump off.
2. Connect a short (6- to 12-inch) piece of Tygon tubing to the sample cap or PRT protruding from the drive rod.
3. Connect one end of the labeled glass bulb to the Tygon tubing.
4. Connect another piece of Tygon tubing 3 feet to 5 feet long to the other end of the glass bulb and to the nipple on the bottom of the vacuum system panel.
5. Open the two stopcocks on the glass bulb.
6. Turn off the vacuum pump.
7. Turn the vacuum line valve to its open position.
8. Purge three times the volume of ambient air within the rods, bulb, and tubing. Equations for figuring out volumes are presented in the Tedlar bag discussion.

9. Turn the vacuum line valve to its closed position. Allow the pressure in the sample train to equalize (the sample line gauge should read zero).
10. Close the stopcocks on the glass bulb.
11. Remove the glass bulb and label it with the appropriate information.

Adsorption Tubes

The following procedure should be used to collect soil gas in adsorption tubes:

1. Connect a short (6- to 12-inch) piece of Tygon tubing to the sample cap or PRT protruding from the drive rod.
2. Connect this piece of tubing to the nipple on the bottom of the vacuum system panel and purge three volumes of air from the drive rod or PRT system as described in the discussion of the Tedlar bag method.
3. Use hemostats to clamp the Tygon tubing attached to the drive rod or PRT.
4. Insert the adsorption tube between the Tygon tubing from the drive rod or PRT and the Tygon tubing attached to the vacuum system panel.
5. Remove the hemostats and draw the required volume of air through the adsorption tube.
6. Remove the adsorption tube and place the appropriate caps on the tube ends.
7. Clearly label package, and ship the samples as required by the laboratory or Tetra Tech and U.S. Environmental Protection Agency (EPA) SOPs.

Soil Gas Sampling Pointers

If the needle on the vacuum line valve does not move, the soil at the sampling depth may be saturated, pore space may be too tight to yield a sample, or sampling train may be plugged. If the needle moves back to zero very quickly, either the soil at the sampling depth is very permeable or a leak is present in the sampling train.

In some soils, the needle may return to zero very slowly. The time it takes for the needle to return to zero is called the "recovery" time. Recovery time should be noted for each sample taken. This information will allow relative comparison of soil permeability. Recovery times of greater than 10 minutes should be

considered suspect. The effect of leakage in the sampling system increases with longer recovery times. After 10 minutes, the operator should consider either changing the sampling depth, location, or length of pullback from the sampling tip, or switching entirely from soil gas sampling to grab sampling and analysis of soil.

2.3.4 Groundwater Sampling

The two options for sampling groundwater using the Geoprobe System follow procedures similar to those presented in Sections 2.3.2 and 2.3.3 above. The sections below detail procedures for using mill-slotted well point samplers and Geoprobe screen point samplers to sample groundwater.

Mill-Slotted Well Point Sampler

Once the mill-slotted well point reaches groundwater, the water will begin to flow through the slots. When the sample is to be analyzed for volatile organic compounds, do not use a vacuum to suck groundwater from the drive rod. If the sample is to be analyzed for other parameters such as metals, semivolatiles, pesticides, or explosives, using a vacuum on the drive rod is acceptable. In all cases, polyethylene tubing can be used as a thieving rod by lowering its end into the drive rod, capping or sealing the tube's top, and then removing it. The preferred method for collecting samples for volatile organic analysis is to use a well mini-bailer. To collect groundwater samples with a mini-bailer, use the following procedures:

1. Raise the hydraulic punch, turn off the hydraulic system, and remove the drive cap.
2. Lower a well mini-bailer into the drive rod until it reaches the bottom. As it reaches the bottom, the check ball on the bailer's end will float in the groundwater and then slowly sink to the bottom.
3. Allow a couple of seconds for the ball to sink and set.
4. Pull the well mini-bailer out of the drive rod. The bailer should contain about 20 milliliters of groundwater.
5. Package and document the samples in accordance with Tetra Tech SOPs No. 016, 017, 018, and 019, or a similar EPA-approved procedure.

If a bailer is not required and volatile organic samples are not being collected, a foot valve sampler, vacuum trap, or peristaltic pump can be used to collect samples. Once the sample has been removed and packaged, the mill-slotted well point can be removed and decontaminated.

Geoprobe Screen Point Sampler

The Geoprobe screen point sampler contains a screen and screen plug that allows water to enter the rod. To collect groundwater samples with a Geoprobe screen point sampler, use the following procedures:

1. Push the sampler below the depth necessary to reach groundwater.
2. Raise the hydraulic punch and replace the drive cap with a pull cap. Also, remove the anvil.
3. Latch the pull cap under the hammer latch, and use the probe lever to lift the drive rod about 18 inches. Because the sampler has a expendable point, the point should stay at the deepest depth, and the screen and screen connector should fall out of the bottom of the sampler. Sometimes, however, the screen stays within the sampler and is lifted the 18 inches with the drive rod.
4. To ensure that the screen is exposed, attach a vice grip or pipe wrench to the rod above the foot of the hydraulic punch and raise the hydraulic punch. Then remove the pull cap and place an extension rod through the tubing to push the screen into place. Additional extension rods can be attached to reach the desired depth.

To remove the groundwater sample for volatile organic analysis, with a well mini-bailer, follow steps 1 through 5 under the mill-slotted well point section above. Tubing can be used as a thieving rod with or without a check valve to collect groundwater samples as well. If the sampler is supplied with the optional PRT expendable point holder, then a PRT adapter can be pushed through the drive rod and threaded into place by following the PRT system Procedures previously discussed. A vacuum trap system or peristaltic pump can then be used to withdraw the sample. The PRT system method, however, should never be used when the sample is to be analyzed for volatile organic compounds because it involves using a vacuum to remove the sample.

3.0 PIEZOMETER AND VAPOR SAMPLING IMPLANT INSTALLATION PROCEDURES

The Geoprobe System's ability to quickly probe into soil allows for easy installation of both piezometers and vapor sampling implants. Both installation procedures are discussed below.

3.1 PIEZOMETER INSTALLATION

Piezometers are tubes that extend to groundwater and enable easy sampling of groundwater on a routine basis (see Figure 10). In addition to installing the piezometer, piezometers must be protected from the weather and from contamination. A well-head protector must therefore be installed around them. In some soil types, preparing the well-head protector may be the first step to installing a piezometer. For this reason, the directions below should be read completely before beginning piezometer installation. If a post-hole digger is to be used for well-head protector installation, Procedure 5 should be performed first. The piezometer should then be advanced through this hole.

To install temporary or permanent piezometers, use the following procedures:

1. Use the hydraulic punch to drive the temporary casing to the desired piezometer installation depth. Use the general procedures outlined in Section 2.3.1 above for details on driving the piezometer casing. The different temporary casings that can be used are described below. Geoprobe Systems also manufactures special drive caps, expendable points, and pull caps that fit these types and sizes of pipe.
 - a) 1-7/16-inch outside diameter by 1-3/16-inch inside diameter, RW-flush threaded pipe can be used as a temporary casing. This casing can be driven to an approximately 25- to 30-foot depth. Two sizes of piezometer wells can be installed inside of the temporary casing: (1) 3/4-inch outside diameter by 1/2-inch inside diameter, polyvinyl chloride (PVC) pipe, or (2) 1-inch outside diameter by 3/4-inch inside diameter, PVC pipe.
 - b) 1-13/16-inch outside diameter by 1-1/2-inch inside diameter, EW-flush threaded pipe can be used as a temporary casing. This casing can be driven to an approximately 15- to 20-foot depth. Three sizes of piezometer wells can be installed inside of the temporary casing: (1) 3/4-inch outside diameter by 1/2-inch inside diameter PVC pipe, or (2) 1-inch outside diameter by 3/4-inch inside diameter, PVC pipe, or (3) 1-1/2-inch outside diameter by 1-inch inside diameter, PVC pipe.
 - c) 1-1/4-inch outside diameter by 1-inch inside diameter, NPT-threaded pipe can be used as a temporary casing. This casing can be driven to an approximately 25- to 30-foot depth. Only 3/4-inch outside diameter by 1/2-inch inside diameter, PVC

pipe piezometer wells can be installed inside of the temporary casing. If using NPT-threaded pipe, couplers are needed to attach each section of pipe.

2. Once the piezometer casing is at the proper depth, remove the drive cap and install the selected size piezometer pipe inside of the temporary casing.
3. Using a pull plate, remove the temporary casing.
4. If the hole stays open, attempt to install a sand pack around the slotted portion of the piezometer, and then place dry granular bentonite on top of the sand pack as a seal. One foot of bentonite is recommended for a good seal.
5. Dig an 8-inch nominal-diameter hole around the piezometer pipe. This hole should extend to a depth of 1.5 to 2 feet. A post-hole digger can be used for this procedure if the hole is dug prior to driving the temporary casing. The bottom 6 inches of this hole should be filled with dry granular or slurry bentonite. The remainder of the hole should be filled with concrete. A steel, locking, aboveground or flush-mount well protector should be inserted into the wet concrete to provide well-head security. A concrete pad can also be constructed around the steel well-head protector.

3.2 VAPOR SAMPLING IMPLANT INSTALLATION

Figure 11 presents diagrams of vapor sampling implants. To install vapor sampling implants, first punch a drive rod to the desired depth using an expendable point holder and an expendable point. Once at the desired sampling depth, use the following procedures:

1. Disengage the expendable point and retract the probe rod about 1 foot by raising the hydraulic punch, replacing the drive cap with a pull cap, removing the anvil, latching the pull cap onto the hydraulic hammer using its latch, and raising the hydraulic punch again using the probe lever.
2. Lock the rod into place so that it does not sink back into the hole by using vice grip pliers or a pipe wrench.
3. Unlatch the pull cap and raise the hydraulic punch again, leaving room to work freely.
4. Remove the pull cap.
5. Attach appropriate stainless-steel tubing to the vapor implant. If tubing is precut, allow 48 inches more than the required depth of the implant.
6. Insert the implant and tubing down the inside diameter of the probe rods until it stops. Note the length of the tubing inserted to ensure that the desired depth has been reached. Allow the excess tubing to extend out of the drive rod's top.

7. Pour glass beads down the inside diameter of the probe rod using a funnel to create a permeable layer around the implant.
8. Use the tubing extending from the drive rod to stir the beads into place. Do not lift up on the tubing while doing so.
9. Position the remaining tubing through the hole on a rod pull plate, and then place the drive rod through that hole.
10. Attach the plate to the hydraulic punch using its chain and slowly pull the rod up another 18 to 24 inches. While the punch pulls the rod, push down on the tubing so that it stays in place.
11. Pour bentonite seal mixture down the inside diameter of the probe rod. Stir the mixture using the tubing as before. The initial mixture may also be topped with distilled water to initiate the bentonite seal depending on the site and on the role the vapor implant is to play.
12. Pull the drive rod from the hole using the probe rod pull plate already attached, and then plug the hole using granular bentonite or a bentonite slurry mixture.

The vapor sampling implant should now be in place and the stainless steel tubing connected to it should be protruding from the ground. The vapor implant tubing should be protected by a well-head protector in the same manner as the top of the piezometer. Procedure 5 in Section 3.1 describes well-head protector installation.

4.0 ROD REMOVAL PROCEDURES

Throughout the above discussions, it has occasionally been necessary to remove drive rods and samplers. The standard removal procedures involve raising the hydraulic punch, turning off the hydraulic system, replacing the drive cap with a pull cap, removing the anvil, and then latching the pull cap under the hammer latch. The hydraulic punch can then be used to pull the rod from the ground.

Two deviations to this procedure often occur. The first deviation is necessary when sampling tubes are to be left inside the hole as the drive rod is removed, especially when soil gas implants or piezometers have been installed. Because of the presence of these sampling tubes, a pull cap cannot be screwed onto the top of the drive rod. Instead, a rod pull plate is used. This plate is a piece of steel with a hole in it large enough for a drive rod to fit through it. The plate has a hook on one end. The tubing and rod are pushed

through the plate, and the pull plate is attached to the latch on the hydraulic punch by a chain. As the punch pulls up, the plate shifts, and the inside of the hole binds on the rod. This binding usually holds the rod to the plate and results in the rod being pulled up as the punch is raised.

The second deviation occurs when the rods have not been pushed perpendicular to the ground. In these cases, a specially designed chain-assisted pull cap is used. This cap looks like a pull cap but has a chain on it that fits under the latch of the hammer. Once the cap is screwed to the drive rod and latched to the probe, raising the probe raises the rod.

In a few cases, drive rods break while in the ground. To retrieve these rods, a rod extractor is used. This extractor looks something like a drill bit and is screwed to the end of a probe rod. A hammer is then used to pound the extractor into the top of the broken rod. The extractor joins the broken rod to the second drive rod so that they can be pulled out together.

5.0 BACKFILLING PROCEDURES

Unless otherwise specified in the site-specific sampling plan, holes made by sampling with Geoprobe System tools are to be backfilled with dry, fine, granular bentonite. Water may be added to activate the bentonite. Tops of the holes may then be filled with soil or concrete as necessary for each particular site.

6.0 DECONTAMINATION PROCEDURES

Between holes, the probe rods and sampling tools must be decontaminated. Because no provisions for decontamination are included in the Geoprobe System, a separate decontamination station must be provided. A wire brush, a barrel brush for reaming out the rods, and soft brushes will clean sticky soil from the probe rods and sampling tools. Follow Tetra Tech SOP No. 002 decontamination procedures when sampling soil or groundwater.

When sampling for soil gas by the standard method, Geoprobe rods and samplers are heated approximately 15 to 20 minutes by a 100,000-British thermal unit heater until they are too hot to touch with the bare hand. They are then allowed to cool before reuse. Do not heat the rods too much or the rod metal will fatigue.

When sampling for soil gas by the PRT method, the probe rods do not have to be decontaminated. However, the PRT expendable point holder and PRT adapter do need to be decontaminated. They can be heated on the dash of the vehicle with the defrost system or scrubbed in Alconox and water. Equipment blank samples can be collected, if necessary, as part of the quality control process.

Sampling plans may have different decontamination requirements. Most plans also require rinsate sample collection as part of the quality control process.

FIGURE 1
GEOPROBE SYSTEM

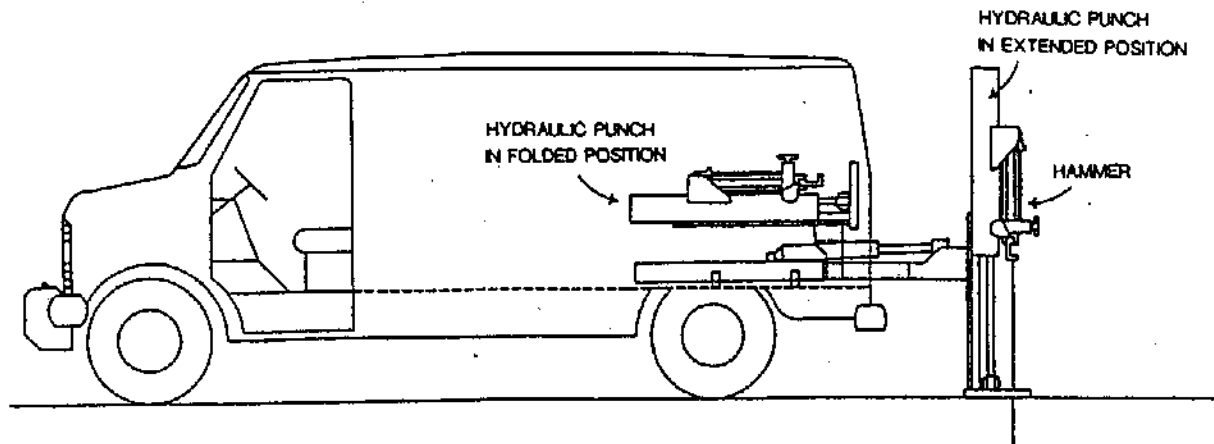
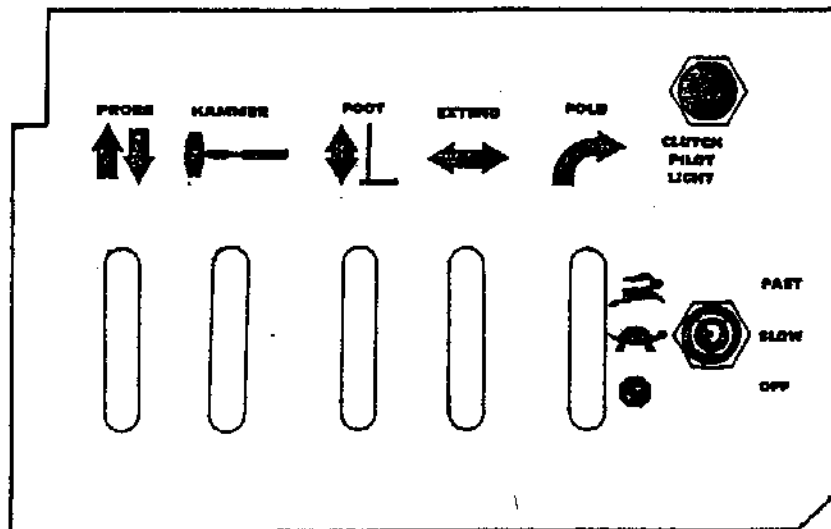
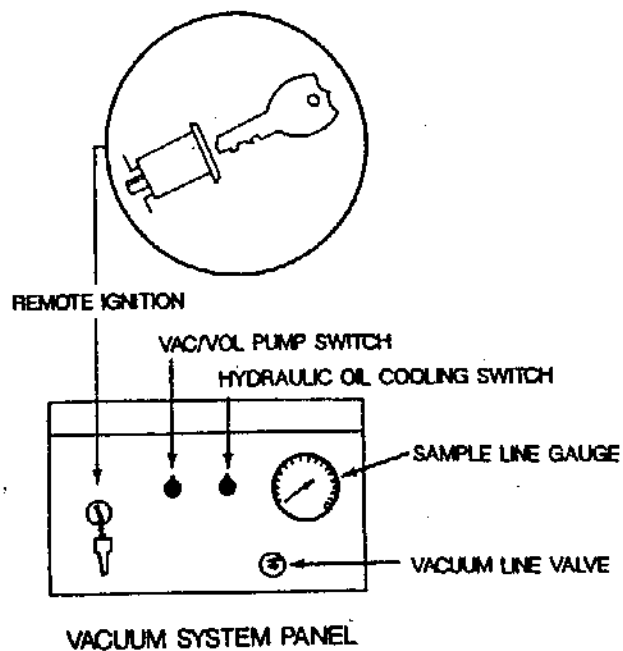


FIGURE 2
CONTROL AND VACUUM SYSTEM PANELS



CONTROL PANEL



VACUUM SYSTEM PANEL

FIGURE 3
GENERAL ACCESSORY TOOLS

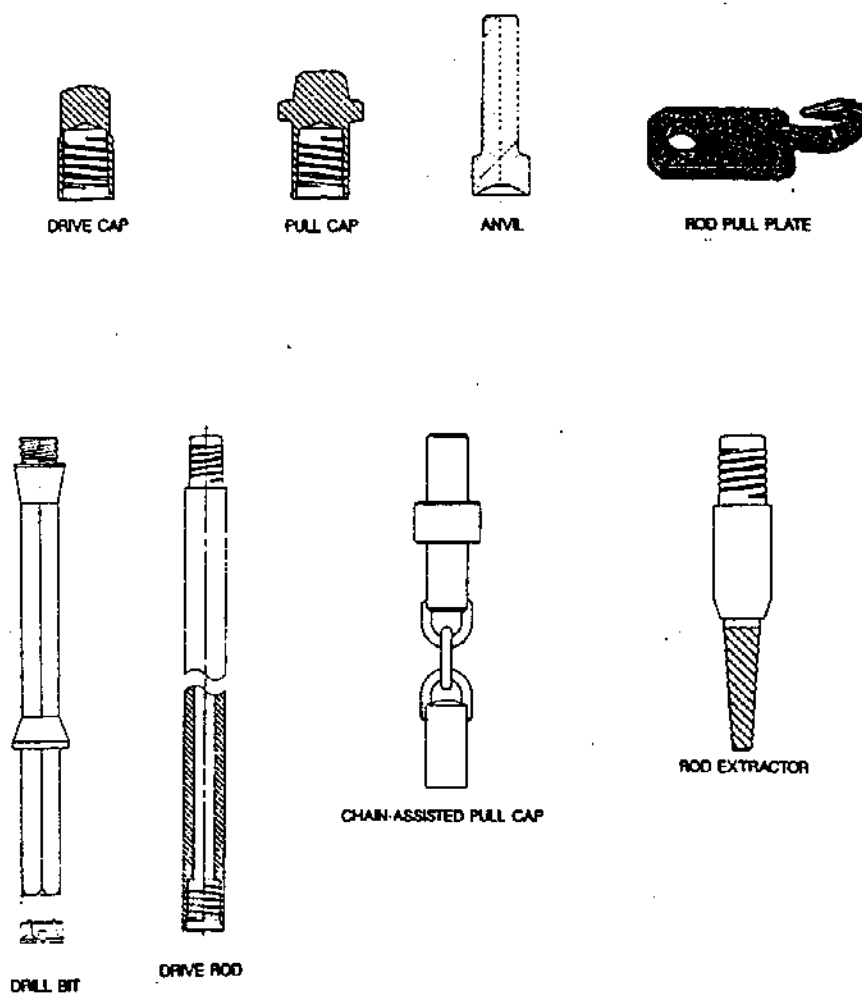


FIGURE 4
SHELBY TUBE ACCESSORIES

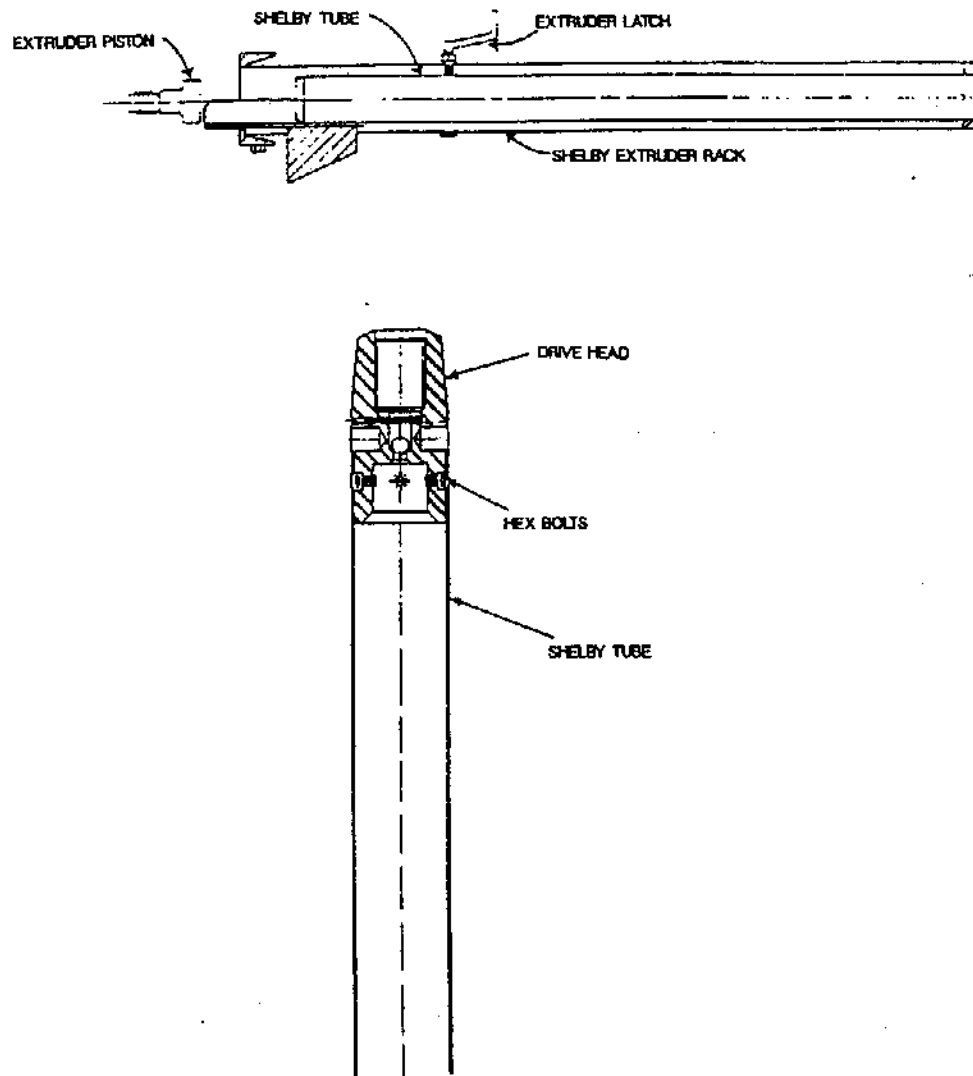


FIGURE 5
PROBE-DRIVE SYSTEM

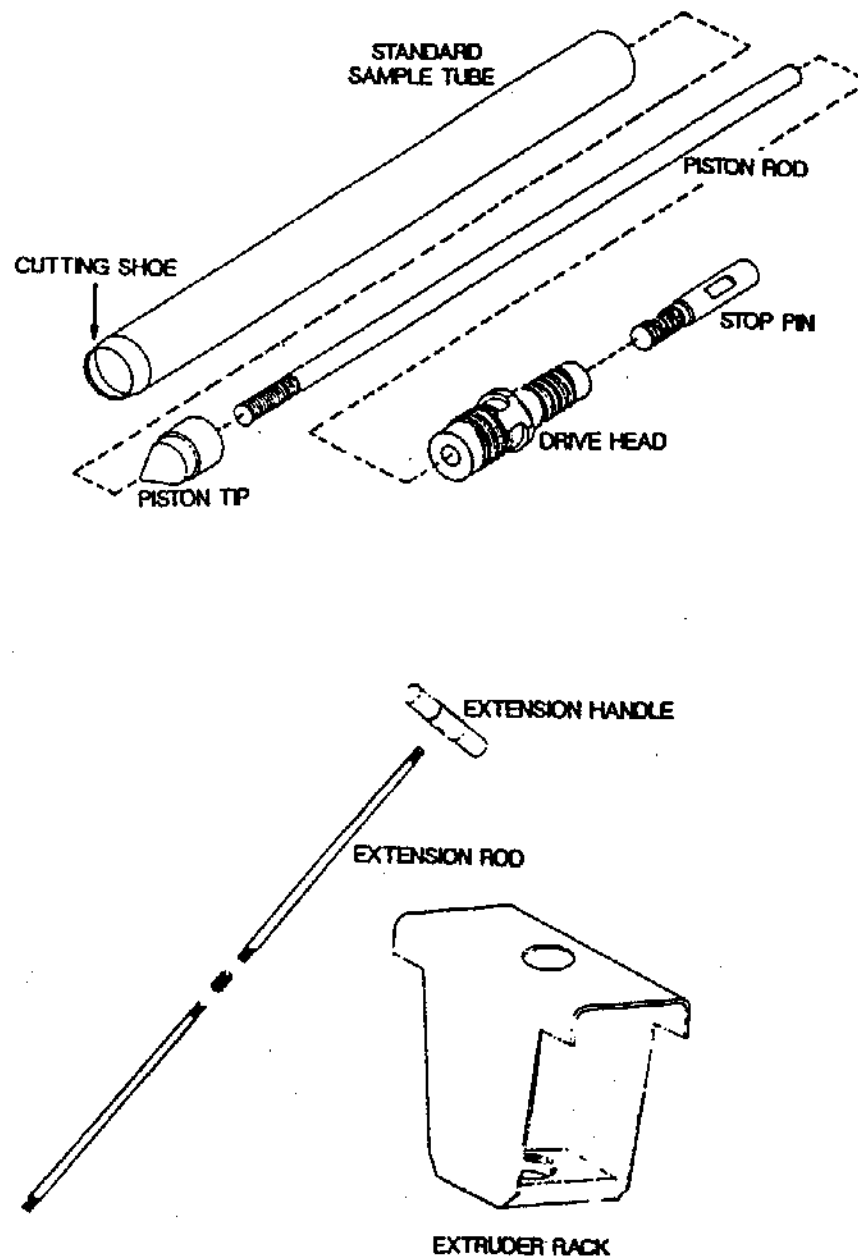
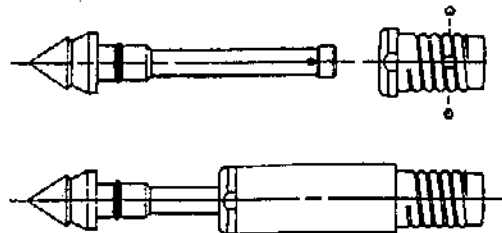


FIGURE 6

STANDARD SOIL GAS TOOLS



RETRACTABLE POINT HOLDER



EXPENDABLE POINT HOLDER



EXPENDABLE POINT



GAS SAMPLING CAP

FIGURE 7
POST-RUN TUBING (PRT) SYSTEM

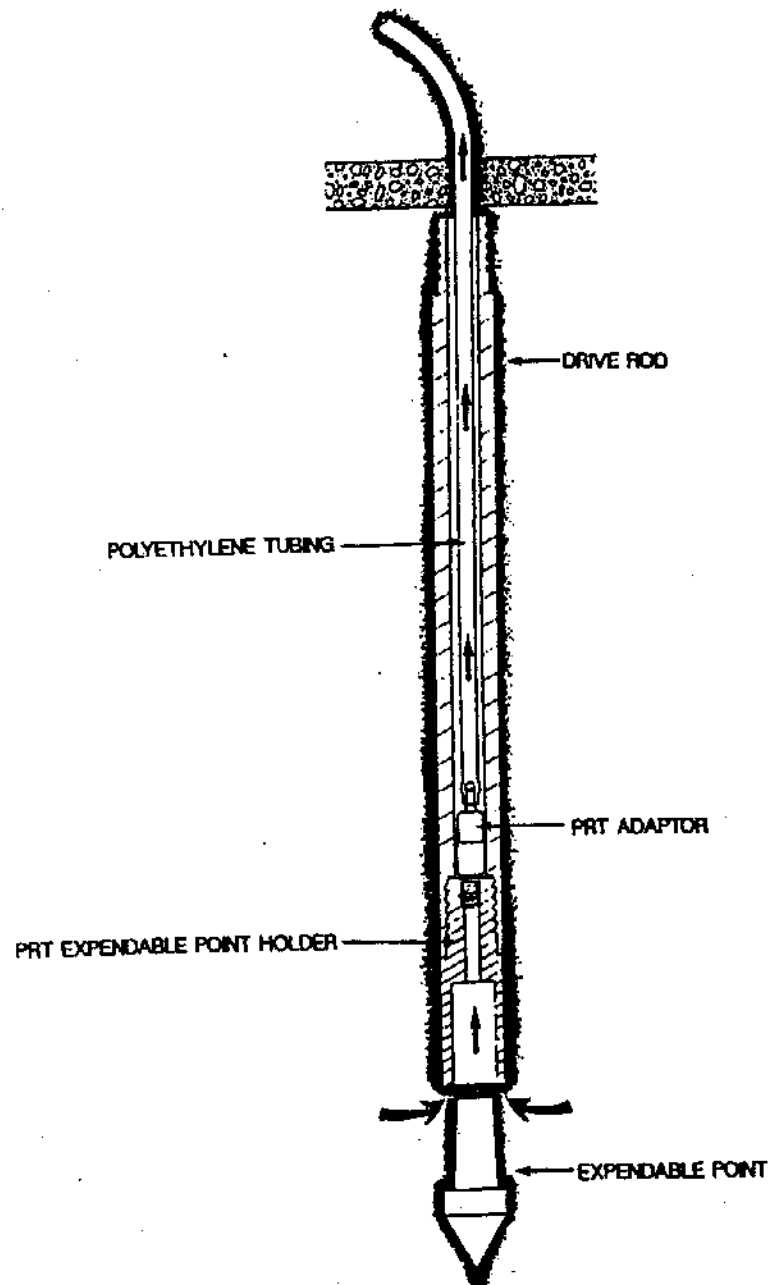
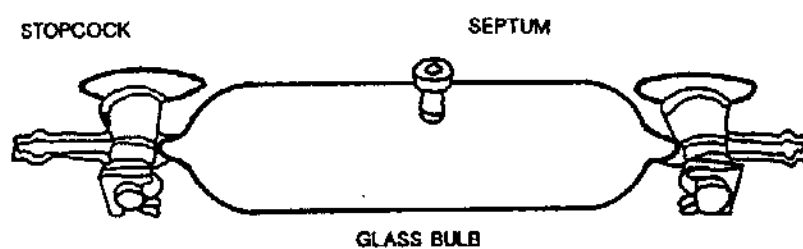


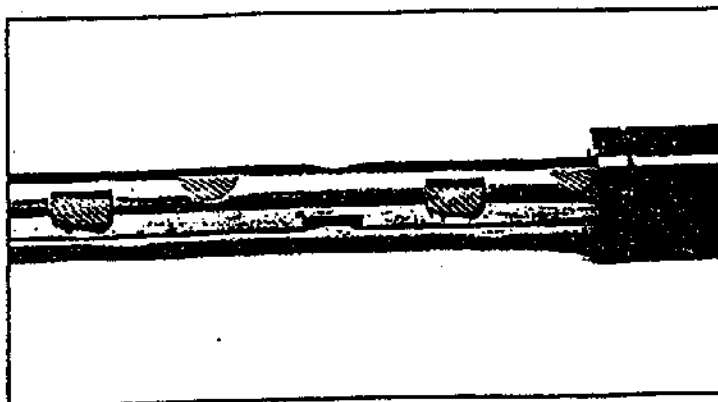
FIGURE 8

SOIL GAS SAMPLE CONTAINER

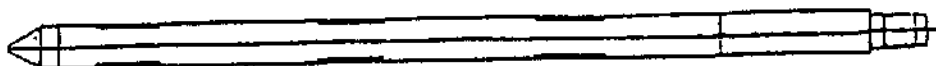


Note: Tedlar bags are also used for collection of soil gas samples; however, they are not shown on this figure.

FIGURE 9
GROUNDWATER SAMPLING TOOLS



SCREEN POINT SAMPLER IN OPEN POSITION



MILL-SLOTTED WELL POINT

FIGURE 10

PIEZOMETER INSTALLATION

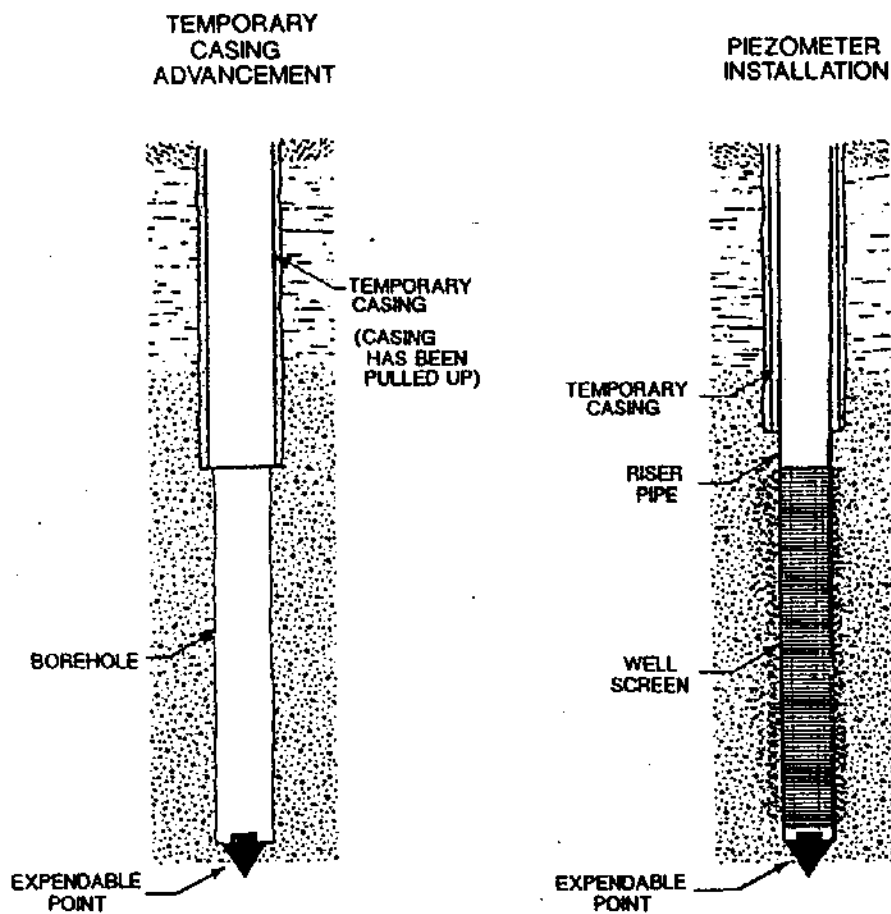
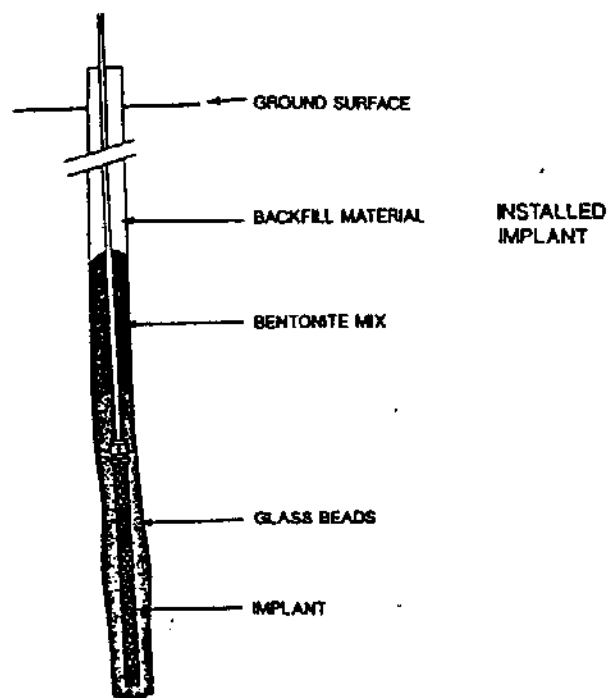
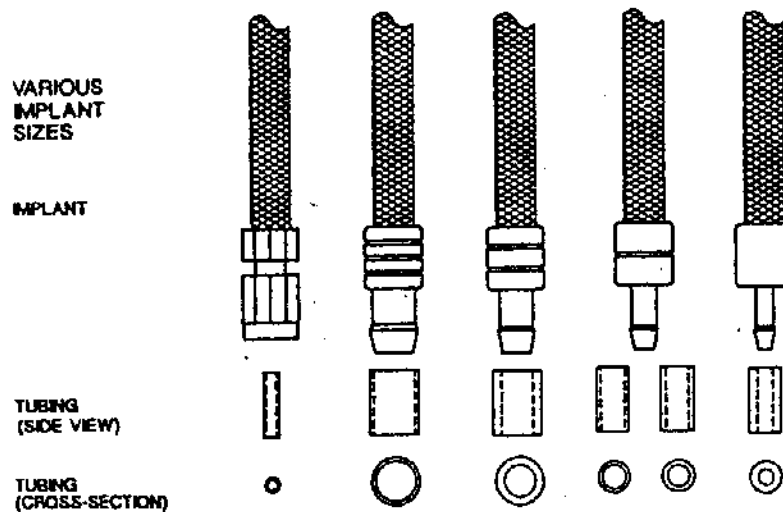


FIGURE 11

VAPOR SAMPLING IMPLANTS



SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

MONITORING WELL INSTALLATION

SOP NO. 020

REVISION NO. 3

Last Reviewed: December 2000

K. Riesing

Quality Assurance Approved

December 19, 2000

Date

1.0 BACKGROUND

Groundwater monitoring wells are designed and installed for a variety of reasons including: (1) detecting the presence or absence of contaminants, (2) collecting groundwater samples representative of in situ aquifer chemical characteristics, or (3) measuring water levels for determining groundwater potentiometric head and groundwater flow direction.

Although detailed specifications for well installation may vary in response to site-specific conditions, some elements of well installation are common to most situations. This standard operating procedure (SOP) discusses common methods and minimum standards for monitoring well installation for Tetra Tech EM Inc. (Tetra Tech) projects. The SOP is based on widely recognized methods described by the U.S. Environmental Protection Agency (EPA) and American Society for Testing and Materials (ASTM). However, well type, well construction, and well installation methods will vary with drilling method, intended well use, subsurface characteristics, and other site-specific criteria. In addition, monitoring wells should be constructed and installed in a manner consistent with all local and state regulations. Detailed specifications for well installation should be identified within a site-specific work plan, sampling plan, or quality assurance project plan (QAPP).

General specifications and installation procedures for the following monitoring well components are included in this SOP:

- Monitoring well materials
 - Casing materials
 - Well screen materials
 - Filter pack materials
 - Annular sealant (bentonite pellets or chips)
 - Grouting materials
 - Tremie pipe
 - Surface completion and protective casing materials
 - Concrete surface pad and bumper posts
 - Uncontaminated water
- Monitoring well installation procedures
 - Well screen and riser placement
 - Filter pack placement
 - Temporary casing retrieval
 - Annular seal placement

- Grouting
- Surface completion and protective casing (aboveground and flush-mount)
- Concrete surface pad and bumper posts
- Permanent and multiple casing well installation
- Recordkeeping procedures
 - Surveying
 - Permits and well construction records
 - Monitoring well identification

Well installation methods will depend to some extent on the boring method. Specific boring or drilling protocols are detailed in other SOPs. The boring method, in turn, will depend on site-specific geology and hydrogeology and project requirements. Boring methods commonly used for well installation include:

- Hollow-stem augering
- Cable tool drilling
- Mud rotary drilling
- Air rotary drilling
- Rock coring

The hollow-stem auger method is preferred in areas where subsurface materials are unconsolidated or loosely consolidated and where the depth of the boring will be less than 100 feet. This maximum effective depth for hollow-stem augering depends on the diameter of the augers, the formation characteristics, and the strength and durability of the drilling equipment. This method is preferred because under the right conditions it is cost effective, addition of water into the subsurface is limited, continuous soil samples can easily be collected, and monitoring wells can easily be constructed within the hollow augers.

Cable tool drilling is a preferred method when the subsurface contains boulders, coarse gravels, or flowing sands, or when the operational depth of the hollow-stem auger is exceeded. However, this method is slow.

Rotary methods are generally used when other methods cannot be used. The use of drilling fluids or large amounts of water to maintain an open borehole, and the difficulty in obtaining representative

samples limit the utility of rotary methods. However, rotary methods can be used to quickly and effectively drill deep wells through consolidated or unconsolidated materials. Modifications to this method such as dual-tube drilling procedures, drill-through casing hammers, or eccentric-type drill systems, can reduce the amount of fluids introduced into the well borehole.

Rock coring is an effective method when drilling in competent consolidated rock. Intact, continuous cores can be obtained, and limited amounts of fluid are required if the formations are not fractured.

1.1 PURPOSE

This SOP establishes the requirements and procedures for monitoring well installation. Monitoring wells should be designed to function properly throughout the duration of the monitoring program. The performance objectives for monitoring well installation are as follows:

- Ensure that the monitoring well will provide water samples representative of in situ aquifer conditions.
- Ensure that the monitoring well construction will last for duration of the project.
- Ensure that the monitoring well will not serve as a conduit for vertical migration of contaminants, particularly vertical migration between discrete aquifers.
- Ensure that the well diameter is adequate for all anticipated downhole monitoring and sampling equipment.

1.2 SCOPE

This SOP applies to the installation of monitoring wells. Although some of the procedures may apply to the installation of water supply wells, this SOP is not intended to cover the design and construction of such wells. The SOP identifies several well drilling methods related to monitoring well installation, but the scope of this SOP does not include drilling methods.

Other relevant SOPs include SOP 002 for decontamination of drilling and well installation equipment, SOP 005 for soil sampling, SOP 021 for monitoring well development, SOPs 010 and 015 for

groundwater sampling from monitoring wells, and SOP 014 for measuring static water levels within monitoring wells.

1.3 DEFINITIONS

Annulus: The space between the monitoring well casing and the wall of the well boring.

Bentonite seal: A colloidal clay seal separating the sand pack from the annular grout seal.

Centralizer: A stainless-steel or plastic spacer that keeps the well screen and casing centered in the borehole.

Filter pack: A clean, uniform sand or gravel placed between the borehole wall and the well screen to prevent formation material from entering the screen.

Grout seal: A fluid mixture of (1) bentonite and water, (2) cement, bentonite, and water, or (3) cement and water placed above the bentonite seal between the casing and the borehole wall to secure the casing in place and keep water from entering the borehole.

Tremie pipe: A rigid pipe used to place the well filter pack, bentonite seal, or grout seal. The tremie pipe is lowered to the bottom of the well or area to be filled and pulled up ahead of the material being placed.

Well casing: A solid piece of pipe, typically polyvinyl chloride (PVC) or stainless steel, used to keep a well open in either unconsolidated material or unstable rock.

Well screen: A PVC or stainless steel pipe with openings of a uniform width, orientation, and spacing used to keep materials other than water from entering the well and to stabilize the surrounding formation.

1.4 REFERENCES

- American Society for Testing and Materials. 1995. *Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers*. D5092-90. West Conshohocken, Pennsylvania.
- California Department of Toxic Substances Control. 1994. *Monitoring Well Design and Construction for Hydrogeologic Characterization*. Guidance for Groundwater Investigations. August.
- Driscoll, F.G. 1986. *Groundwater and Wells (Second Edition)*. Johnson Division, UOP, Inc. St. Paul, Minnesota.
- U.S. Environmental Protection Agency (EPA). 1986. *RCRA Ground Water Monitoring Technical Enforcement Guidance Document*. Office of Solid Waste and Emergency Response. Washington, DC. OSWER-9950-1. September.
- EPA. 1991. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells*. Office of Research and Development, Environmental Monitoring Systems Laboratory. Washington, DC. EPA/600-4-89/034. March. On-Line Address: <http://www.epa.gov/swerst1/cat/wwelldct.pdf>
- EPA. 1994. *Monitor Well Installation*. Environmental Response Team SOP #2048 (Rev. #0.0, 03/18/96). On-Line Address: http://www.ert.org/media_resrcs/media_resrcs.asp?Child1=

1.5 REQUIREMENTS AND RESOURCES

Well installation requires a completed boring with stable or supported walls. The type of drilling rig needed to complete the boring and the well construction materials required for monitoring well installation will depend on the drilling method used, the geologic formations present, and chemicals of concern in groundwater. The rig and support equipment used to drill the borehole is usually used to install the well. Under most conditions, the following items are also required for the proper installation of monitoring wells:

- Tremie pipe and funnel
- Bentonite pellets or chips
- Grouting supplies
- Casing materials
- Well screen materials
- Filter pack materials

- Surface completion materials (protective casing, lockable and watertight well cover, padlock)
- Electronic water level sounding device for water level measurement
- Measuring tape with weight for measuring the depth of the well and determining the placement of filter pack materials
- Decontamination equipment and supplies
- Site-specific work plan, field sampling plan, health and safety plan, and QAPP
- Monitoring Well Completion Record (see Figure 1)

2.0 MONITORING WELL INSTALLATION PROCEDURES

This section presents standard procedures for monitoring well installation and is divided into three subsections. Section 2.1 addresses monitoring well construction materials, while Section 2.2 describes typical monitoring well installation procedures. Section 2.3 addresses recordkeeping requirements associated with monitoring well installation. Monitoring well installation procedures described in work plans, sampling plans, and QAPPs should be fully consistent with the procedures outlined in this SOP as well as any applicable local and state regulations and guidelines.

2.1 MONITORING WELL CONSTRUCTION MATERIALS

Monitoring well construction materials should be specified in the site-specific work plan as well as in the statement of work for any subcontractors assisting in the well installation. Well construction materials that come in contact with groundwater should not measurably alter the chemical quality of groundwater samples with regard to the constituents being examined. The riser, well screen, and filter pack and annular sealant placement equipment should be steam cleaned or high-pressure water cleaned immediately prior to well installation. Alternatively, these materials can be certified by the manufacturer as clean and delivered to the site in protective wrapping. Samples of the filter pack, annular seal, and mixed grout should be retained as a quality control measure until at least one round of groundwater sampling and analysis is completed.

This section discusses material specifications for the following well construction components: casing, well screen, filter pack, annular sealant (bentonite pellets or chips), grout, tremie pipes, surface

completion components (protective casing, lockable and water tight cap, and padlock), concrete surface pad, and uncontaminated water. Figure 2 shows the construction details of a typical monitoring well.

2.1.1 Casing Materials

The material type and minimum wall thickness of the casing should be adequate to withstand the forces of installation. If the casing has not been certified as clean by the manufacturer or delivered to and maintained in clean condition at the site, the casing should be steam cleaned or high-pressure water cleaned with water from a source of known chemistry immediately prior to installation (see Tetra Tech SOP No. 002). The ends of each casing section should be either flush-threaded or beveled for welding.

Schedule 40 or Schedule 80 PVC casing is typically used for monitoring well installation. Either type of casing is appropriate for monitoring wells with depths less than 100 feet below ground surface (bgs). If the well is deeper than 100 feet bgs, Schedule 80 PVC should be used.

Stainless steel used for well casing is typically Type 304 and is of 11-gauge thickness.

2.1.2 Well Screen Materials

Well screens should be new, machine-slotted or continuous wrapped wire-wound, and composed of materials most suited for the monitoring environment based on site characterization findings. Well screens are generally constructed of the same materials used for well casing (PVC or stainless steel). The screen should be plugged at the bottom with the same material as the well screen. Alternatively, a short (1- to 2-foot) section of casing material with a bottom (sump) should be attached below the screen. This assembly must be able to withstand installation and development stresses without becoming dislodged or damaged. The length of the slotted area should reflect the interval to be monitored.

If the well screen has not been certified as clean by the manufacturer or delivered to and maintained in clean condition at the site, the screen should be steam cleaned or high-pressure water cleaned with water from a source of known chemistry immediately prior to installation (see Tetra Tech SOP No. 002).

The minimum internal diameter of the well screen should be chosen based on the particular application. A minimum diameter of 2 inches is usually needed to allow for the introduction and withdrawal of sampling devices. Typical monitoring well screen diameters are 2 inches and 4 inches.

The slot size of the well screen should be determined relative to (1) the grain size of particles in the aquifer to be monitored and (2) the gradation of the filter pack material.

Screen length and monitoring well diameter will depend on site-specific considerations such as intended well use, contaminants of concern, and hydrogeology. Some specific considerations include the following:

- Water table wells should have screens of sufficient length and diameter to monitor the water table and provide sufficient sample volume under high and low water table conditions.
- Wells with low recharge should have screens of sufficient length and diameter so that adequate sample volume can be collected.
- Wells should be screened over sufficiently short intervals to allow for monitoring of discrete migration pathways.
- Where light nonaqueous-phase liquids (LNAPL) or contaminants in the upper portion of a hydraulic unit are being monitored, the screen should be set so that the upper portion of the water-bearing zone is below the top of the screen.
- Where dense nonaqueous-phase liquids (DNAPL) are being monitored, the screen should be set within the lower portion of the water-bearing zone, just above a relatively impermeable lithologic unit.
- The screened interval should not extend across an aquiclude or aquitard.
- If contamination is known to be concentrated within a portion of a saturated zone, the screen should be constructed in a manner that minimizes the potential for cross-contamination within the aquifer.
- If downhole geophysical surveys are to be conducted, the casing and screen must be of sufficient diameter and constructed of the appropriate material to allow for effective use of the geophysical survey tools.
- If aquifer tests are to be conducted in a monitoring well, the slot size must allow sufficient flux to produce the required drawdown and recovery. The diameter of the well must be sufficient to house the pump and monitoring equipment, and allow sufficient

water flux (in combination with the screen slot size) to produce the required drawdown or recovery.

2.1.3 Filter Pack Materials

The primary filter pack consists of a granular material of known chemistry and selected grain size and gradation. The filter pack is installed in the annulus between the well screen and the borehole wall. The grain size and gradation of the filter pack are selected to stabilize the hydrologic unit adjacent to the screen and to prevent formation material from entering the well during development. After development, a properly filtered monitoring well is relatively free of turbidity.

A secondary filter pack is a layer of material placed in the annulus directly above the primary filter pack and separates the filter pack from the annular sealant. The secondary filter pack should be uniformly graded fine sand, with 100 percent by weight passing through a No. 30 U.S. Standard sieve, and less than 2 percent by weight passing through a No. 200 U.S. Standard sieve.

2.1.4 Annular Sealant (Bentonite Pellets or Chips)

The materials used to seal the annulus may be prepared as a slurry or used as dry pellets, granules, or chips. Sealants should be compatible with ambient geologic, hydrogeologic, and climatic conditions and any man-induced conditions anticipated to occur during the life of the well.

Bentonite (sodium montmorillonite) is the most commonly used annular sealant and is furnished in sacks or buckets in powder, granular, pelletized, or chip form. Bentonite should be obtained from a commercial source and should be free of impurities that may adversely impact the water quality in the well. Pellets are compressed bentonite powder in roughly spherical or disk shapes. Chips are large, coarse, irregularly shaped units of bentonite. The diameter of the pellets or chips should be less than one-fifth the width of the annular space into which they will be placed in order to reduce the potential for bridging. Granules consist of coarse particles of unaltered bentonite, typically smaller than 0.2 inch in diameter. Bentonite slurry is prepared by mixing powdered or granular bentonite with water from a source of known chemistry.

2.1.5 Grouting Materials

The grout backfill that is placed above the bentonite annular seal is ordinarily liquid slurry consisting of either (1) a bentonite (powder, granules, or both) base and water, (2) a bentonite and Portland cement base and water, or (3) a Portland cement base and water. Often, bentonite-based grouts are used when flexibility is desired during the life of the well installation (for example, to accommodate freeze-thaw cycles). Cement- or bentonite-based grouts are often used when cracks in the surrounding geologic material must be filled or when adherence to rock units, or a rigid setting is desired.

Each type of grout mixture has slightly different characteristics that may be appropriate under various physical and chemical conditions. However, quick-setting cements containing additives are not recommended for use in monitoring well installation because additives may leach from the cement and influence the chemistry of water samples collected from the well.

2.1.6 Tremie Pipe

A tremie pipe is used to place the filter pack, annular sealant, and grouting materials into the borehole. The tremie pipe should be rigid, have a minimum internal diameter of 1.0 inch, and be made of PVC or steel. The length of the tremie pipe should be sufficient to extend to the full depth of the monitoring well.

2.1.7 Surface Completion and Protective Casing Materials

Protective casings that extend above the ground surface should be made of aluminum, steel, stainless steel, cast iron, or a structural plastic. The protective casing should have a lid with a locking device to prevent vandalism. Sufficient clearance, usually 6 inches, should be maintained between the top of the riser and the top of protective casing. A water-tight well cap should be placed on the top of the riser to seal the well from surface water infiltration in the event of a flood. A weep hole should be drilled in the casing a minimum of 6 inches above the ground surface to enable water to drain out of the annular space.

Flush-mounted monitoring wells (wells that do not extend above ground surface) require a water-tight protective cover of sufficient strength to withstand heavy traffic. The well riser should be fitted with a locking water-tight cap.

2.1.8 Concrete Surface Pad and Bumper Posts

A concrete surface pad should be installed around each well when the outer protective casing is installed. The surface pad should be formed around the well casing. Concrete should be placed into the formed pad and into the borehole (on top of the grout), typically to a depth of 1 to 3 feet bgs (depending on state, federal, and local regulations). The protective casing is then installed into the concrete. As a general guideline, if the well casing is 2 inches in diameter, the concrete pad should be 3 feet square and 4 inches thick. If the well casing is 4 inches in diameter, the pad should be 4 feet square and 6 inches thick. Round concrete pads are also acceptable.

The finished pad should be sloped so that drainage flows away from the protective casing and off the pad. The finished pad should extend at least 1 inch below grade. If the monitoring wells are located in high traffic areas, a minimum of three bumper posts should be installed around the pad to protect the well. Bumper posts, consisting of steel pipes 3 to 4 inches in diameter and at least 5 feet long, should be installed in a radial pattern around the protective casing, beyond the edges of the cement pad. The base of the bumper posts should be installed 2 feet bgs in a concrete footing; the top of the post should be capped or filled with concrete.

2.1.9 Uncontaminated Water

Water used in the drilling process, to prepare grout mixtures, and to decontaminate the well screen, riser, and annular sealant injection equipment, should be obtained from a source of known chemistry. The water should not contain constituents that could compromise the integrity of the monitoring well installation.

2.2 MONITORING WELL INSTALLATION PROCEDURES

This section describes the procedures used to install a single-cased monitoring well, with either temporary casing or hollow-stem augers to support the walls of the boring in unconsolidated formations. The procedures are described in the order in which they are conducted, and include: (1) placement of well screen and riser pipe, (2) placement of filter pack, (3) progressive retrieval of temporary casing, (4) placement of annular seal, (5) grouting, (6) surface completion and installation of protective casing, and (7) installation of concrete pad and bumper posts.

The additional steps necessary to install a well with permanent or multiple casing strings are described at the end of this section.

2.2.1 Well Screen and Riser Placement

After the total depth of the boring is confirmed and the well screen depth interval and the height of the aboveground completion are determined, the screen and riser is assembled from the bottom up as it is lowered down the hole. The following procedures should be followed:

1. Measure the total depth of the boring using a weighted tape.
2. Determine the length of screen and casing materials required to construct the well.
3. Assemble the well parts from the bottom up, starting with the well sump or cap, well screen, and then riser pipe. Progressively lower the assembled length of pipe.
4. The length of the assembled pipe should not extend above the top of the installation rig.

The well sump or cap, well screen, and riser should be certified clean by the manufacturer or should be decontaminated before assembly and installation. No grease, oil, or other contaminants should contact any portion of the assembly. Flush joints should be tightened, and welds should be water tight and of good quality. The riser should extend above grade and be capped temporarily to prevent entrance of foreign materials during the remaining well completion procedures.

When the well screen and riser assembly is lowered to the predetermined level, it may float and require a method to hold it in place. For borings drilled using cable tool or air rotary drilling methods, centralizers should be attached to the riser at intervals of between 20 and 40 feet.

2.2.2 Filter Pack Placement

The filter pack is placed after the well screen and riser assembly has been lowered into the borehole. The steps below should be followed:

1. Determine the volume of the annular space in the filter pack interval. The filter pack should extend from the bottom of the borehole to at least 2 feet above the top of the well screen.
2. Assemble the required material (sand pack and tremie pipe).
3. Lower a clean or decontaminated tremie pipe down the annulus to within 1 foot of the base of the hole.
4. Pour the sand down the tremie pipe using a funnel; pour only the quantity estimated to fill the first foot.
5. Check the depth of sand in the hole using a weighted tape.
6. Pull the drill casing up ahead of the sand to keep the sand from bridging.
7. Continue with this process (steps 4 through 6) until the filter pack is at the appropriate depth.

If bridging of the filter pack occurs, break out the bridge prior to adding additional filter pack material. For wells less than 30 feet deep installed inside hollow-stem augers, the sand may be poured in 1-foot lifts without a tremie pipe.

Sufficient measurements of the depth to the filter pack material and the depth of the bottom of the temporary casing should be made to ensure that the casing bottom is always above the filter pack. The filter pack should extend 2 feet above the well screen (or more if required by state or local regulations). However, the filter pack should not extend across separate hydrogeologic units. The final depth interval, volume, and type of filter pack should be recorded on the Monitoring Well Completion Record (Figure 1).

A secondary filter pack may be installed above the primary filter pack to prevent the intrusion of the bentonite grout seal into the primary filter pack. A measured volume of secondary filter material should be added to extend 1 to 2 feet above the primary filter pack. As with the primary filter pack, a secondary filter pack must not extend into an overlying hydrologic unit. An on-site geologist should evaluate the

need for a secondary filter pack by considering the gradation of the primary filter pack, the hydraulic head difference between adjacent units, and the potential for grout intrusion into the primary filter pack.

The secondary filter material is poured into the annular space through tremie pipe as described above. Water from a source of known chemistry may be added to help place the filter pack into its proper location. The tremie pipe or a weighed line inserted through the tremie pipe can be used to measure the top of the secondary filter pack as work progresses. The amount and type of secondary filter pack used should be recorded on the Monitoring Well Completion Record (Figure 1).

2.2.3 Temporary Casing Retrieval

The temporary casing or hollow-stem auger should be withdrawn in increments. Care should be taken to minimize lifting the well screen and riser assembly during withdrawal of the temporary casing or auger. It may be necessary to place the top head of the rig on the riser to hold it down. To limit borehole collapse in formations consisting of unconsolidated materials, the temporary casing or hollow-stem auger is usually withdrawn until the lowest point of the casing or auger is at least 2 feet, but no more than 5 feet, above the filter pack. When the geologic formation consists of consolidated materials, the lowest point of the casing or auger should be at least 5 feet, but no more than 10 feet, above the filter pack. In highly unstable formations, withdrawal intervals may be much less. After each increment, the depth to the primary filter pack should be measured to check that the borehole has not collapsed or that bridging has not occurred.

2.2.4 Annular Seal Placement

A bentonite pellet, chip, or slurry seal should be placed between the borehole and the riser on top of the primary or secondary filter pack. This seal retards the movement of grout into the filter pack. The thickness of the bentonite seal will depend on state and local regulations, but the seal should generally be between 3 and 5 feet thick.

The bentonite seal should be installed using a tremie pipe, lowered to the top of the filter pack and slowly raised as the bentonite pellets or slurry fill the space. Care must be taken so that bentonite pellets or

chips do not bridge in the augers or tremie pipe. The depth of the seal should be checked with a weighted tape or the tremie pipe.

If a bentonite pellet or chip seal is installed above the water level, water from a known source should be added to allow proper hydration of the bentonite. Sufficient time should be allowed for the bentonite seal to hydrate. The volume and thickness of the bentonite seal should be recorded on the Monitoring Well Completion Record (Figure 1).

2.2.5 Grouting

Grouting procedures vary with the type of well design. The volume of grout needed to backfill the remaining annular space should be calculated and recorded on the Monitoring Well Completion Record (Figure 1). The use of alternate grout materials, including grouts containing gravel, may be necessary to control zones of high grout loss. Bentonite grouts should not be used in arid regions because of their propensity to desiccate. Typical grout mixtures include the following:

- Bentonite grout: about 1 to 1.25 pounds of bentonite mixed with 1 gallon of water
- Cement-bentonite grout: about 5 pounds of bentonite and one 94-pound bag of cement mixed with 7 to 8 gallons of water
- Cement grout: one 94-pound bag of cement mixed with 6 to 7 gallons of water

The grout should be installed by gravity feed through a tremie pipe. The grout should be mixed in batches in accordance with the appropriate requirements and then pumped into the annular space until full-strength grout flows out at the ground surface without evidence of drill cuttings or fluid. The tremie pipe should then be removed to allow the grout to cure.

The riser should not be disturbed until the grout sets and cures for the amount of time necessary to prevent a break in the seal between the grout and riser. For bentonite grouts, curing times are typically around 24 hours; curing times for cement grouts are typically 48 to 72 hours. However, the curing time required will vary with grout content and climatic conditions. The curing time should be documented in the Monitoring Well Completion Record (Figure 1).

2.2.6 Surface Completion and Protective Casing

Aboveground completion of the monitoring well should begin once the grout has set (no sooner than 24 hours after the grout was placed). The protective casing is lowered over the riser and set into the cured grout. The protective casing should extend below the ground surface to a depth below the frost line (typically 3 to 5 feet, depending on local conditions). The protective casing is then cemented in place. A minimum of 6 inches of clearance should be maintained between the top of the riser and the protective casing. A 0.5-inch diameter drainage or weep hole should be drilled in the protective casing approximately 6 inches above the ground surface to enable water to drain out of the annular space between the casing and riser. A water-tight cap should be placed on top of the riser to seal the well from surface water infiltration in the event of a flood. A lock should be placed on the protective casing to prevent vandalism.

For flush-mounted monitoring wells, the well cover should be raised above grade and the surrounding concrete pad sloped so that water drains away from the cover. The flush-mount completion should be installed in accordance with applicable state and local regulations.

2.2.7 Concrete Surface Pad and Bumper Posts

The concrete pad installed around the monitoring well should be sloped so that the drainage will flow away from the protective casing and off the pad. The finished pad should extend at least 1 inch below grade. If the monitoring wells are located in high traffic areas, a minimum of three bumper posts should be installed in a radial pattern around the protective casing, outside the cement pad. Specifications for concrete surface pads and bumper posts are described in Section 2.1.8.

2.2.8 Permanent and Multiple Casing Well Installation

When wells are installed through multiple saturated zones, special well construction methods should be used to assure well integrity and limit the potential for cross-contamination between geologic zones. Generally, these types of wells are necessary if relatively impermeable layers separate hydraulic units. Two procedures that may be used are described below.

In the first procedure, the borehole is advanced to the base of the first saturated zone. Casing is then anchored in the underlying impermeable layer (aquitard) by advancing the casing at least 1 foot into the aquitard and grouting to the surface. After the grout has cured, a smaller diameter borehole is drilled through the grout. This procedure is repeated until the zone of interest is reached. After the zone is reached, a conventional well screen and riser are set. A typical well constructed in this manner is shown on Figure 3.

A second acceptable procedure involves driving a casing through several saturated layers while drilling ahead of the casing. However, this method is not acceptable when the driven casing may structurally damage a competent aquitard or aquiclude and result in cross-contamination of the two saturated layers. This method should also be avoided when highly contaminated groundwater or nonaqueous-phase contamination may be dragged down into underlying uncontaminated hydrologic units.

2.3 RECORDKEEPING PROCEDURES

Recordkeeping procedures associated with monitoring well installation are described in the following sections. These include procedures for surveying, obtaining permits, completing well construction records, and identifying monitoring wells.

2.3.1 Surveying

Latitude, longitude, and elevation at the top of the riser should be determined for each monitoring well. A permanent notch or black mark should be made on the north side of the riser. The top of the riser and ground surface should be surveyed.

2.3.2 Permits and Well Construction Records

Local and state regulations should be reviewed prior to monitoring well installation, and any required well permits should be in-hand before the driller is scheduled.

Monitoring well installation activities should be documented in both the field logbook and on the Monitoring Well Completion Record (Figure 1). Geologic logs should be completed and, if necessary, filed with the appropriate regulatory agency within the appropriate time frame.

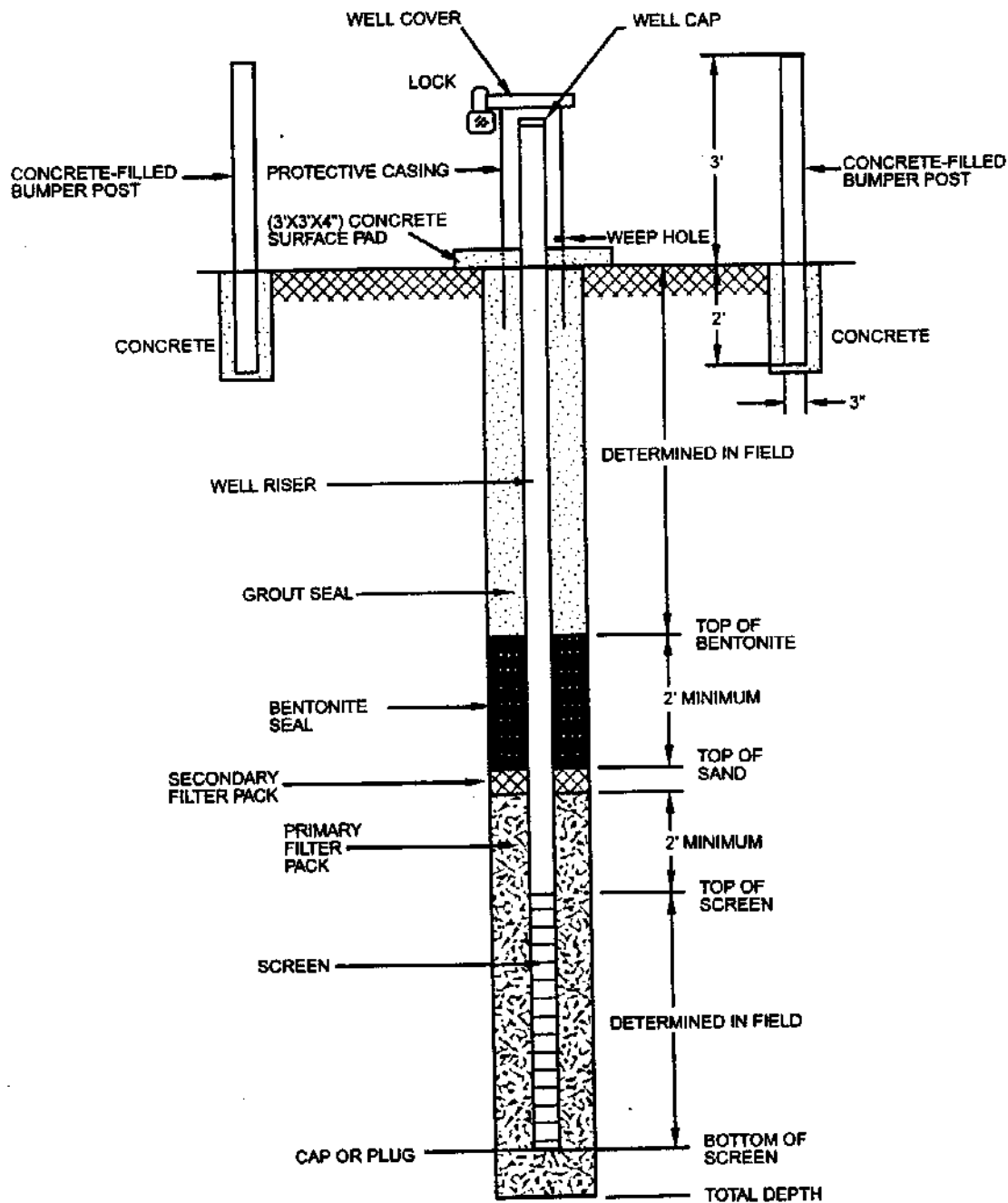
2.3.3 Monitoring Well Identification

Each monitoring well should have an individual well identification number or name. The well identification may be stamped in the metal surface upon completion or permanently marked by using another method. Current state and local regulations should be checked for identification requirements (such as township, range, section, or other identifiers in the well name).

FIGURE 1
 MONITORING WELL COMPLETION RECORD

MONITORING WELL COMPLETION RECORD		
MONITORING WELL MONITORING WELL NO.: _____ PROJECT: _____ SITE: _____ BOREHOLE NO.: _____ WELL PERMIT NO.: _____ TOC TO BOTTOM OF WELL: _____	SURFACE COMPLETION <input type="checkbox"/> FLUSH MOUNT <input type="checkbox"/> ABOVE GROUND WITH BUMPER POST <input type="checkbox"/> CONCRETE <input type="checkbox"/> ASPHALT	SURVEY INFORMATION TOC ELEVATION: _____ GROUND SURFACE ELEVATION: _____ NORTHING: _____ EASTING: _____ DATE SURVEYED: _____ SURVEY CO.: _____
DRILLING INFORMATION DRILLING BEGAN: _____ DATE: _____ TIME: _____ WELL INSTALLATION BEGAN: _____ DATE: _____ TIME: _____ WELL INSTALLATION FINISHED: _____ DATE: _____ TIME: _____ DRILLING CO.: _____ DRILLER: _____ LICENSE: _____ DRILL RIG: _____ DRILLING METHOD: <input type="checkbox"/> HOLLOW-STEM AUGER <input type="checkbox"/> AIR ROTARY <input type="checkbox"/> OTHER: _____ DIAMETER OF AUGERS: ID: _____ OD: _____		ANNULAR SEAL VOLUME CALCULATED: _____ AMOUNT USED: _____ <input type="checkbox"/> GROUT FORMULA (PERCENTAGES) PORTLAND CEMENT: _____ BENTONITE: _____ WATER: _____ <input type="checkbox"/> PREPARED MIX PRODUCT: _____ MFG. BY: _____ METHOD INSTALLED: <input type="checkbox"/> POURED <input type="checkbox"/> TREMIE <input type="checkbox"/> OTHER: _____
WELL CASING <input type="checkbox"/> SCHEDULE 40 PVC <input type="checkbox"/> OTHER: _____ PRODUCT: _____ MFG. BY: _____ CASING DIAMETER: ID: _____ OD: _____ LENGTH OF CASING: _____	BENTONITE SEAL VOLUME CALCULATED: _____ AMOUNT USED: _____ <input type="checkbox"/> PELLETS, SIZE: _____ <input type="checkbox"/> CHIPS, SIZE: _____ <input type="checkbox"/> OTHER: _____ PRODUCT: _____ MFG. BY: _____ METHOD INSTALLED: <input type="checkbox"/> POURED <input type="checkbox"/> TREMIE <input type="checkbox"/> OTHER: _____ AMOUNT OF WATER USED: _____	WELL SCREEN <input type="checkbox"/> SCHEDULE 40 PVC <input type="checkbox"/> OTHER: _____ PRODUCT: _____ MFG. BY: _____ CASING DIAMETER: ID: _____ OD: _____ SLOT SIZE: _____ LENGTH OF SCREEN: _____
BOREHOLE BACKFILL AMOUNT CALCULATED: _____ AMOUNT USED: _____ <input type="checkbox"/> BENTONITE CHIPS, SIZE: _____ <input type="checkbox"/> BENTONITE PELLETS, SIZE: _____ <input type="checkbox"/> SLURRY: _____ <input type="checkbox"/> FORMATION COLLAPSE: _____ <input type="checkbox"/> OTHER: _____ PRODUCT: _____ MFG. BY: _____ METHOD INSTALLED: <input type="checkbox"/> POURED <input type="checkbox"/> TREMIE <input type="checkbox"/> OTHER: _____	FILTER PACK <input type="checkbox"/> PREPACKED FILTER VOLUME CALCULATED: _____ AMOUNT USED: _____ <input type="checkbox"/> SAND, SIZE: _____ PRODUCT: _____ MFG. BY: _____ METHOD INSTALLED: <input type="checkbox"/> POURED <input type="checkbox"/> TREMIE <input type="checkbox"/> OTHER: _____ WATER LEVEL: _____ (BTWC AFTER WELL INSTALLATION)	CENTRALIZERS USED? <input type="checkbox"/> YES <input type="checkbox"/> NO CENTRALIZER DEPTHS: _____
LEGEND BGS = BELOW GROUND SURFACE BTWC = BELOW TOP OF CASING NA = NOT APPLICABLE NR = NOT RECORDED TOC = TOP OF CASING ID = INSIDE DIAMETER OD = OUTSIDE DIAMETER		

FIGURE 2
MONITORING WELL CONSTRUCTION DIAGRAM



SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

GENERAL EQUIPMENT DECONTAMINATION

SOP NO. 002

REVISION NO. 2

Last Reviewed: December 1999

K. Riesing

Quality Assurance Approved

February 2, 1993

Date

1.0 BACKGROUND

All nondisposable field equipment must be decontaminated before and after each use at each sampling location to obtain representative samples and to reduce the possibility of cross-contamination.

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for decontaminating equipment in the field.

1.2 SCOPE

This SOP applies to decontaminating general nondisposable field equipment. To prevent contamination of samples, all sampling equipment must be thoroughly cleaned prior to each use.

1.3 DEFINITIONS

Alconox: Nonphosphate soap

1.4 REFERENCES

U.S. Environmental Protection Agency (EPA). 1992. "RCRA Ground-Water Monitoring: Draft Technical Guidance. Office of Solid Waste. Washington, DC. EPA/530-R-93-001. November.

EPA. 1994. "Sampling Equipment Decontamination." Environmental Response Team SOP #2006 (Rev. #0.0, 08/11/94). On-Line Address: http://204.46.140.12/media_resrcs/media_resrcs.asp?Child1=

1.5 REQUIREMENTS AND RESOURCES

The equipment required to conduct decontamination is as follows:

- Scrub brushes
- Large wash tubs or buckets
- Squirt bottles

- Alconox
- Tap water
- Distilled water
- Plastic sheeting
- Aluminum foil
- Methanol or hexane
- Dilute (0.1 N) nitric acid

2.0 PROCEDURE

The procedures below discuss decontamination of personal protective equipment (PPE), drilling and monitoring well installation equipment, borehole soil sampling equipment, water level measurement equipment, and general sampling equipment.

2.1 PERSONAL PROTECTIVE EQUIPMENT DECONTAMINATION

Personnel working in the field are required to follow specific procedures for decontamination prior to leaving the work area so that contamination is not spread off-site or to clean areas. All used disposable protective clothing, such as Tyvek coveralls, gloves, and booties, will be containerized for later disposal. Decontamination water will be containerized in 55-gallon drums.

Personnel decontamination procedures will be as follows:

1. Wash neoprene boots (or neoprene boots with disposable booties) with Liquinox or Alconox solution and rinse with clean water. Remove booties and retain boots for subsequent reuse.
2. Wash outer gloves in Liquinox or Alconox solution and rinse in clean water. Remove outer gloves and place into plastic bag for disposal.
3. Remove Tyvek or coveralls. Containerize Tyvek for disposal and place coveralls in plastic bag for reuse.
4. Remove air purifying respirator (APR), if used, and place the spent filters into a plastic bag for disposal. Filters should be changed daily or sooner depending on use and application. Place respirator into a separate plastic bag after cleaning and disinfecting.
5. Remove disposable gloves and place them in plastic bag for disposal.

6. Thoroughly wash hands and face in clean water and soap.

2.2 DRILLING AND MONITORING WELL INSTALLATION EQUIPMENT DECONTAMINATION

All drilling equipment should be decontaminated at a designated location on-site before drilling operations begin, between borings, and at completion of the project.

Monitoring well casing, screens, and fittings are assumed to be delivered to the site in a clean condition. However, they should be steam cleaned on-site prior to placement downhole. The drilling subcontractor will typically furnish the steam cleaner and water.

After cleaning the drilling equipment, field personnel should place the drilling equipment, well casing and screens, and any other equipment that will go into the hole on clean polyethylene sheeting.

The drilling auger, bits, drill pipe, temporary casing, surface casing, and other equipment should be decontaminated by the drilling subcontractor by hosing down with a steam cleaner until thoroughly clean. Drill bits and tools that still exhibit particles of soil after the first washing should be scrubbed with a wire brush and then rinsed again with a high-pressure steam rinse.

All wastewater from decontamination procedures should be containerized.

2.3 BOREHOLE SOIL SAMPLING EQUIPMENT DECONTAMINATION

The soil sampling equipment should be decontaminated after each sample as follows:

1. Prior to sampling, scrub the split-barrel sampler and sampling tools in a bucket using a stiff, long bristle brush and Liquinox or Alconox solution.
2. Steam clean the sampling equipment over the rinsate tub and allow to air dry.
3. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
4. Containerize all water and rinsate.

5. Decontaminate all pipe placed down the hole as described for drilling equipment.

2.4 WATER LEVEL MEASUREMENT EQUIPMENT DECONTAMINATION

Field personnel should decontaminate the well sounder and interface probe before inserting and after removing them from each well. The following decontamination procedures should be used:

1. Wipe the sounding cable with a disposable soap-impregnated cloth or paper towel.
2. Rinse with deionized organic-free water.

2.5 GENERAL SAMPLING EQUIPMENT DECONTAMINATION

All nondisposable sampling equipment should be decontaminated using the following procedures:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of protection as was used for sampling.
3. To decontaminate a piece of equipment, use an Alconox wash; a tap water wash; a solvent (methanol or hexane) rinse, if applicable or dilute (0.1 N) nitric acid rinse, if applicable; a distilled water rinse; and air drying. Use a solvent (methanol or hexane) rinse for grossly contaminated equipment (for example, equipment that is not readily cleaned by the Alconox wash). The dilute nitric acid rinse may be used if metals are the analyte of concern.
4. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
5. Containerize all water and rinsate.

SOP APPROVAL FORM

TETRA TECH EM INC.

ENVIRONMENTAL STANDARD OPERATING PROCEDURE

PACKAGING AND SHIPPING SAMPLES

SOP NO. 019

REVISION NO. 5

Last Reviewed: January 2000

K. Miesing

Quality Assurance Approved

January 28, 2000

Date

1.0 BACKGROUND

In any sampling program, the integrity of a sample must be ensured from its point of collection to its final disposition. Procedures for classifying, packaging, and shipping samples are described below. Steps in the procedures should be followed to ensure sample integrity and to protect the welfare of persons involved in shipping and receiving samples. When hazardous substances and dangerous goods are sent by common carrier, their packaging, labeling, and shipping are regulated by the U.S. Department of Transportation (DOT) Hazardous Materials Regulations (HMR, *Code of Federal Regulations*, Title 49 [49 CFR] Parts 106 through 180) and the International Air Transportation Association (IATA) Dangerous Goods Regulations (DGR).

1.1 PURPOSE

This standard operating procedure (SOP) establishes the requirements and procedures for packaging and shipping samples. It has been prepared in accordance with the U.S. Environmental Protection Agency (EPA) "Sampler's Guide to the Contract Laboratory Program (CLP)," the DGR, and the HMR. Sample packaging and shipping procedures described in this SOP should be followed for all sample packaging and shipping. Deviations from the procedures in this SOP must be documented in a field logbook. This SOP assumes that samples are already collected in the appropriate sample jars and that the sample jars are labeled and tagged appropriately.

1.2 SCOPE

This SOP applies to sample classification, packaging, and shipping.

1.3 DEFINITIONS

Custody seal: A custody seal is a tape-like seal. Placement of the custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been packaged for shipping.

Dangerous goods: Dangerous goods are articles or substances that can pose a significant risk to health, safety, or property when transported by air; they are classified as defined in Section 3 of the DGR (IATA 1999).

Environmental samples: Environmental samples include drinking water, most groundwater and ambient surface water, soil, sediment, treated municipal and industrial wastewater effluent, and biological specimens. Environmental samples typically contain low concentrations of contaminants and when handled require only limited precautionary procedures.

Hazardous Materials Regulations: The HMR are DOT regulations for the shipment of hazardous materials by air, water, and land; they are located in 49 CFR 106 through 180.

Hazardous samples: Hazardous samples include dangerous goods and hazardous substances. Hazardous samples shipped by air should be packaged and labeled in accordance with procedures specified by the DGR; ground shipments should be packaged and labeled in accordance with the HMR.

Hazardous substance: A hazardous substance is any material, including its mixtures and solutions, that is listed in Appendix A of 49 CFR 172.101 and its quantity, in one package, equals or exceeds the reportable quantity (RQ) listed in the appendix.

IATA Dangerous Goods Regulations: The DGR are regulations that govern the international transport of dangerous goods by air. The DGR are based on the International Civil Aviation Organization (ICAO) Technical Instructions. The DGR contain all of the requirements of the ICAO Technical Instructions and are more restrictive in some instances.

Nonhazardous samples: Nonhazardous samples are those samples that do not meet the definition of a hazardous sample and **do not** need to be packaged and shipped in accordance with the DGR or HMR.

Overpack: An enclosure used by a single shipper to contain one or more packages and to form one handling unit (IATA 1999). For example, a cardboard box may be used to contain three fiberboard boxes to make handling easier and to save on shipping costs.

1.4 REFERENCES

U.S. Department of Transportation, Transport Canada, and the Secretariat of Communications and Transportation of Mexico (DOT and others). 1996. "1996 North American Emergency Response Guidebook."

International Air Transport Association (IATA). 1997. "Guidelines for Instructors of Dangerous Courses."

IATA. 1999. "Dangerous Goods Regulations." 40th Edition.

U.S. Environmental Protection Agency. 1996. "Sampler's Guide to the Contract Laboratory Program." Office of Solid Waste and Emergency Response. Washington, DC. EPA/540/R-96/032. On-Line Address: <http://www.epa.gov/oerrpage/superfund/programs/clp/guidance.htm#sample>

1.5 REQUIREMENTS AND RESOURCES

The procedures for packaging and shipping **nonhazardous** samples require the following:

- Coolers
- Ice
- Vermiculite, bubble wrap, or similar cushioning material
- Chain-of-custody forms and seals
- Airbills
- Resealable plastic bags for sample jars and ice
- Tape (strapping and clear)

The procedures for packaging and shipping **hazardous** samples require the following:

- Ice
- Vermiculite or other non-combustible, absorbent packing material
- Chain-of-custody forms and seals
- Appropriate dangerous goods airbills and emergency response information to attach to the airbill

6. Thoroughly wash hands and face in clean water and soap.

2.2 DRILLING AND MONITORING WELL INSTALLATION EQUIPMENT DECONTAMINATION

All drilling equipment should be decontaminated at a designated location on-site before drilling operations begin, between borings, and at completion of the project.

Monitoring well casing, screens, and fittings are assumed to be delivered to the site in a clean condition. However, they should be steam cleaned on-site prior to placement downhole. The drilling subcontractor will typically furnish the steam cleaner and water.

After cleaning the drilling equipment, field personnel should place the drilling equipment, well casing and screens, and any other equipment that will go into the hole on clean polyethylene sheeting.

The drilling auger, bits, drill pipe, temporary casing, surface casing, and other equipment should be decontaminated by the drilling subcontractor by hosing down with a steam cleaner until thoroughly clean. Drill bits and tools that still exhibit particles of soil after the first washing should be scrubbed with a wire brush and then rinsed again with a high-pressure steam rinse.

All wastewater from decontamination procedures should be containerized.

2.3 BOREHOLE SOIL SAMPLING EQUIPMENT DECONTAMINATION

The soil sampling equipment should be decontaminated after each sample as follows:

1. Prior to sampling, scrub the split-barrel sampler and sampling tools in a bucket using a stiff, long bristle brush and Liquinox or Alconox solution.
2. Steam clean the sampling equipment over the rinsate tub and allow to air dry.
3. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
4. Containerize all water and rinsate.

5. Decontaminate all pipe placed down the hole as described for drilling equipment.

2.4 WATER LEVEL MEASUREMENT EQUIPMENT DECONTAMINATION

Field personnel should decontaminate the well sounder and interface probe before inserting and after removing them from each well. The following decontamination procedures should be used:

1. Wipe the sounding cable with a disposable soap-impregnated cloth or paper towel.
2. Rinse with deionized organic-free water.

2.5 GENERAL SAMPLING EQUIPMENT DECONTAMINATION

All nondisposable sampling equipment should be decontaminated using the following procedures:

1. Select an area removed from sampling locations that is both downwind and downgradient. Decontamination must not cause cross-contamination between sampling points.
2. Maintain the same level of protection as was used for sampling.
3. To decontaminate a piece of equipment, use an Alconox wash; a tap water wash; a solvent (methanol or hexane) rinse, if applicable or dilute (0.1 N) nitric acid rinse, if applicable; a distilled water rinse; and air drying. Use a solvent (methanol or hexane) rinse for grossly contaminated equipment (for example, equipment that is not readily cleaned by the Alconox wash). The dilute nitric acid rinse may be used if metals are the analyte of concern.
4. Place cleaned equipment in a clean area on plastic sheeting and wrap with aluminum foil.
5. Containerize all water and rinsate.

- Resealable plastic bags for sample jars and ice
- Tape (strapping and clear)
- Appropriate shipping containers as specified in the DGR
- Labels that apply to the shipment such as hazard labels, address labels, "Cargo Aircraft Only" labels, and package orientation labels (up arrows)

2.0 PROCEDURES

The following procedures apply to packaging and shipping nonhazardous and hazardous samples.

2.1 SAMPLE CLASSIFICATION

Prior to sample shipment, it must be determined whether the sample is subject to the DGR. Samples subject to these regulations shall be referred to as hazardous samples. If the hazardous sample is to be shipped by air, then the DGR should be followed. Any airline, including FedEx, belonging to IATA must follow the DGR. As a result, FedEx **may not** accept a shipment that is packaged and labeled in accordance with the HMR (although in most cases, the packaging and labeling would be the same for either set of regulations). The HMR states that a hazardous material may be transported by aircraft in accordance with the ICAO Technical Instruction (49 CFR 171.11) upon which the DGR is based. Therefore, the use of the DGR for samples to be shipped by air complies with the HMR, but not vice versa.

Most environmental samples are not hazardous samples and do not need to be packaged in accordance with any regulations. Hazardous samples are those samples that can be classified as specified in Section 3 of the DGR, can be found in the List of Dangerous Goods in the DGR in bold type, are considered a hazardous substance (see definition), or are mentioned in "Section 2 - Limitations" of the DGR for countries of transport or airlines (such as FedEx). The hazard classifications specified in the DGR (and the HMR) are as follows:

Class 1 - Explosives

Division 1.1 - Articles and substances having a mass explosion hazard

shipped and any noncompressed gas that is either flammable or toxic. A compressed gas is defined as having a pressure over 40 pounds per square inch (psi) absolute (25 psi gauge). Most air samples and empty cylinders that did not contain a flammable or toxic gas are exempt from the regulations. An empty hydrogen cylinder, as in a flame ionization detector (FID), is considered a dangerous good unless it is properly purged with nitrogen in accordance with the HMR. A landfill gas sample is usually considered a flammable gas because it may contain a high percentage of methane. Class 3, flammable liquids, are based on the boiling point and flash point of a substance. Most class 3 samples include solvents, oil, gas, or paint-related material collected from drums, tanks, or pits. Division 6.1, toxic substances, is based on oral toxicity (LD_{50} [lethal dose that kills 50 percent of the test animals]), dermal toxicity (LD_{50} values), and inhalation toxicity (LC_{50} [lethal concentration that kills 50 percent of the test animals] values).

Division 6.1 substances include pesticides and cyanide. Class 7, radioactive material, is defined as any article or substance with a specific activity greater than 70 kiloBecquerels (kBq/kg) (0.002 [microCuries per gram [μ Ci/g]]). If the specific activity exceeds this level, the sample should be shipped in accordance with Section 10 of the DGR. Class 8, corrosives, are based on the rate at which a substance destroys skin tissue or corrodes steel; they are not based on pH. Class 8 materials include the concentrated acids used to preserve water samples. Preserved water samples are not considered class 8 substances and should be packaged as nonhazardous samples. Class 9, miscellaneous dangerous goods, are substances that present a danger but are not covered by any other hazard class. Examples of class 9 substances include asbestos, polychlorinated biphenyls (PCB), and dry ice.

Unlike the DGR, the HMR includes combustible liquids in hazard class 3. The definition of a combustible liquid is specified in 49 CFR 173.120 of the HMR. The HMR has an additional class, ORM-D, that is not specified in the DGR. "ORM-D material" refers to a material such as a consumer commodity, that although otherwise subject to the HMR, presents a limited hazard during transport due to its form, quantity, and packaging. It must be a material for which exceptions are provided in the table of 49 CFR 172.101. The DGR lists consumer commodities as a class 9 material.

In most instances, the hazard of a material sampled is unknown because no laboratory testing has been conducted. A determination as to the suspected hazard of the sample must be made using knowledge of the site, field observations, field tests, and other available information.

According to 40 CFR 261.4(d) and (e), samples transported to a laboratory for testing or treatability studies, including samples of hazardous wastes, are **not** hazardous wastes. FedEx will not accept a shipment of hazardous waste.

2.2 PACKAGING NONHAZARDOUS SAMPLES

Nonhazardous samples, after being appropriately containerized, labeled, and tagged, should be packaged in the following manner. Note that these are general instructions; samplers should be aware of any client-specific requirements concerning the placement of custody seals or other packaging provisions.

1. Place the sample in a resealable plastic bag.
2. Place the bagged sample in a cooler and pack it to prevent breakage.
3. Prevent breakage of bottles during shipment by either wrapping the sample container in bubble wrap, or lining the cooler with a noncombustible material such as vermiculite. Vermiculite is especially recommended because it will absorb any free liquids inside the cooler. It is recommended that the cooler be lined with a large plastic garbage bag before samples, ice, and absorbent packing material are placed in the cooler.
4. Add a sufficient quantity of ice to the cooler to cool samples to 4 °C. Ice should be double bagged in resealable plastic bags to prevent the melted ice from leaking out. As an option, a temperature blank (a sample bottle filled with distilled water) can be included with the cooler.
5. Seal the completed chain-of-custody forms in a plastic bag and tape the plastic bag to the inside of the cooler lid.
6. Tape any instructions for returning the cooler to the inside of the lid.
7. Close the lid of the cooler and tape it shut by wrapping strapping tape around both ends and hinges of the cooler at least once. Tape shut any drain plugs on the cooler.
8. Place two signed custody seals on the cooler, ensuring that each one covers the cooler lid and side of the cooler. Place clear plastic tape over the custody seals.
9. Place address labels on the outside of the cooler.
10. Ship samples overnight by a commercial carrier such as FedEx.

2.3 PACKAGING HAZARDOUS SAMPLES

The procedures for packaging hazardous samples are summarized below. Note that according to the DGR, all spellings must be exactly as they appear in the List of Dangerous Goods, and only approved abbreviations are acceptable. The corresponding HMR regulations are provided in parentheses following any DGR referrals. The HMR must be followed only if shipping hazardous samples by ground transport.

1. Determine the proper shipping name for the material to be shipped. All proper shipping names are listed in column B of the List of Dangerous Goods table in Section 4 of the DGR (or column 2 of the Hazardous Materials Table in 49 CFR 172.101). In most instances, a generic name based on the hazard class of the material is appropriate. For example, a sample of an oily liquid collected from a drum with a high photoionization detector (PID) reading should be packaged as a flammable liquid. The proper shipping name chosen for this sample would be "flammable liquid, n.o.s." The abbreviation "n.o.s." stands for "not otherwise specified" and is used for generic shipping names. Typically, a specific name, such as acetone, should be inserted in parentheses after most n.o.s. descriptions. However, a technical name is not required when shipping a sample for testing purposes and the components are not known. If shipping a hazardous substance (see definition), then the letters "RQ" must appear in front of the proper shipping name.
2. Determine the United Nations (UN) identification number, class or division, subsidiary risk if any, required hazard labels, packing group, and either passenger aircraft or cargo aircraft packing instructions based on the quantity of material being shipped in one package. This information is provided in the List of Dangerous Goods (or Hazardous Materials Table in 49 CFR 172.101) under the appropriate proper shipping name. A "Y" in front of a packing instruction indicates a limited quantity packing instruction. If shipping dry ice or a limited quantity of a material, then UN specification shipping containers do not need to be used.
3. Determine the proper packaging required for shipping the samples. Except for limited quantity shipments and dry ice, these are UN specification packages that have been tested to meet the packing group of the material being shipped. Specific testing requirements of the packages is listed in Section 6 of the DGR (or 49 CFR 178 of the HMR). All UN packages are stamped with the appropriate UN specification marking. Prior planning is required to have the appropriate packages on hand during a sampling event where hazardous samples are anticipated. Most samples can be shipped in either a 4G fiberboard box, a 1A2 steel drum, or a 1H2 plastic drum. Drums can be purchased in 5- and 20-gallon sizes and are ideal for shipping multiple hazardous samples. When FedEx is used to ship samples containing PCBs, the samples must be shipped in an inner metal packaging (paint can) inside a 1A2 outer steel drum. This method of packaging PCB samples is in accordance with FedEx variation FX-06, listed in Section 2 of the DGR.

4. Place each sample jar in a separate resealable plastic bag. Some UN specification packagings contain the sample jar and plastic bag to be used when shipping the sample.
5. Place each sealed bag inside the approved UN specification container (or other appropriate container if a limited quantity or dry ice) and pack with enough noncombustible, absorbent, cushioning material (such as vermiculite) to prevent breakage and to absorb liquid.
6. Place chain-of-custody forms in a resealable plastic bag and either attach it to the inside lid of the container or place it on top inside the container. Place instructions for returning the container to the shipper on the inside lid of the container as appropriate. Close and seal the shipping container in the manner appropriate for the type of container being used.
7. Label and mark each package appropriately. All irrelevant markings and labels need to be removed or obliterated. All outer packagings must be marked with proper shipping name, UN identification number, and name and address of the shipper and the recipient. For carbon dioxide, solid (dry ice), the net weight of the dry ice within the package needs to be marked on the outer package. For limited quantity shipments, the words "limited quantity" or "LTD. QTY." must be marked on the outer package. Affix the appropriate hazard label to the outer package. If the material being shipped contains a subsidiary hazard, then a subsidiary hazard label must also be affixed to the outer package. The subsidiary hazard label is identical to the primary hazard label except that the class or division number is not present. It is acceptable to obliterate the class or division marking on a primary hazard label and use it as the subsidiary hazard label. If using cargo aircraft only packing instructions, then the "Cargo Aircraft Only" label must be used. Package orientation labels (up arrows) must be placed on opposite sides of the outer package. Figure 1 depicts a properly marked and labeled package.
8. If using an overpack (see definition), mark and label the overpack and each outer packaging within the overpack as described in step 7. In addition, the statement "INNER PACKAGES COMPLY WITH PRESCRIBED SPECIFICATIONS" must be marked on the overpack.
9. Attach custody seals, and fill out the appropriate shipping papers as described in Section 2.4.

2.4 SHIPPING PAPERS FOR HAZARDOUS SAMPLES

A "Shippers Declaration for Dangerous Goods" and "Air Waybill" must be completed for each shipment of hazardous samples. FedEx supplies a Dangerous Goods Airbill to its customers; the airbill combines both

the declaration and the waybill. An example of a completed Dangerous Goods Airbill is depicted in Figure

2. A shipper's declaration must contain the following:

- Name and address of shipper and recipient
- Air waybill number (not applicable to the HMR)
- Page ____ of ____
- Deletion of either "Passenger and Cargo Aircraft" or "Cargo Aircraft Only," whichever does not apply
- Airport or city of departure
- Airport or city of destination
- Deletion of either "Non-Radioactive" or "Radioactive," which ever does not apply
- The nature and quantity of dangerous goods. This includes the following information in the following order (obtained from the List of Dangerous Goods in the DGR): proper shipping name, class or division number, UN identification number, packing group number, subsidiary risk, quantity in liters or kilograms (kg), type of packaging used, packing instructions, authorizations, and additional handling information. Authorizations include the words "limited quantity" or "LTD. QTY." if shipping a limited quantity, any special provision numbers listed in the List of Dangerous Goods in the DGR, and the variation "USG-14" when a technical name is required after the proper shipping name but not entered because it is unknown.
- Signature for the certification statement
- Name and title of signatory
- Place and date of signing certification
- A 24-hour emergency response telephone number for use in the event of an incident involving the dangerous good
- Emergency response information attached to the shipper's declaration. This information can be in the form of a material safety data sheet or the applicable North American Emergency Response Guidebook (NAERG; DOT 1996) pages. Figure 3 depicts the appropriate NAERG emergency response information for "Flammable liquids, n.o.s." as an example.

Note that dry ice does not require an attached shipper's declaration. However, the air waybill must include the following on it: "Dry ice, 9, UN1845, ____ x ____ kg." The blanks must include the number of packages and the quantity in kg in each package. If using FedEx to ship dry ice, the air waybill includes a box specifically for dry ice. Simply check the appropriate box and enter in the number of packages and quantity in each package.

The HMR requirements for shipping papers are located in 49 CFR 172 Subpart C.

3.0 POTENTIAL PROBLEMS

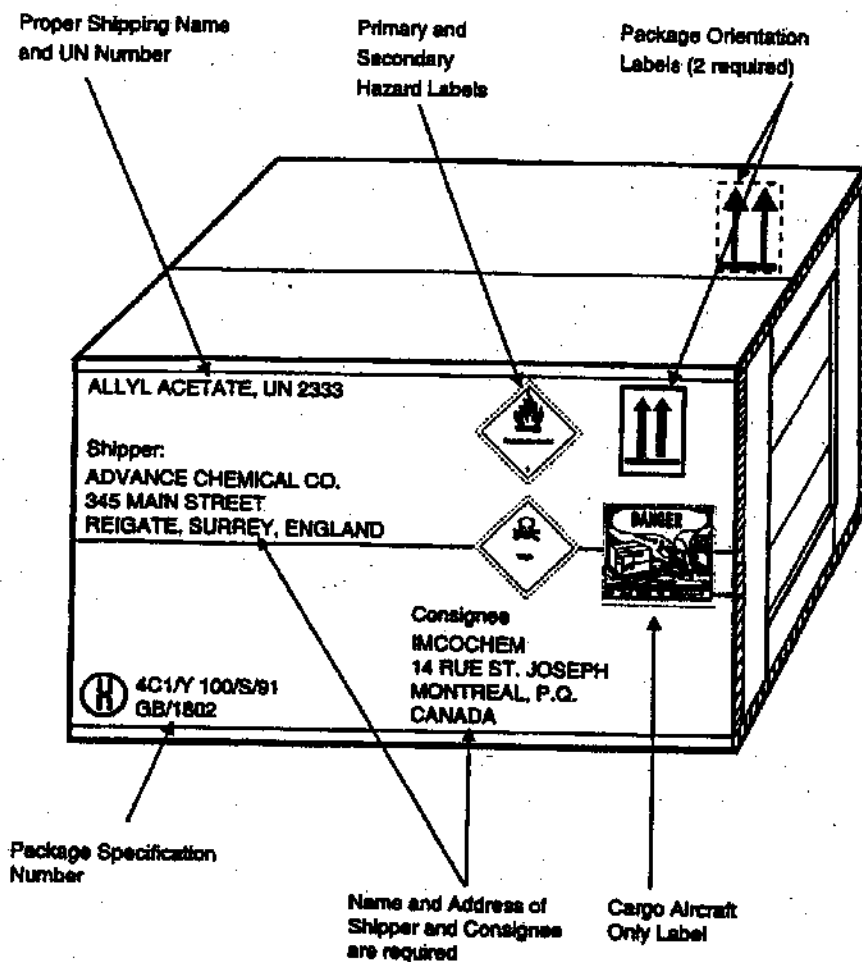
The following potential problems may occur during sample shipment:

- **Leaking package.** If a package leaks, the carrier may open the package, return the package, and if a dangerous good, inform the Federal Aviation Administration (FAA), which can result in fines.
- **Improper labeling and marking of package.** If mistakes are made in labeling and marking the package, the carrier will most likely notice the mistakes and return the package to the shipper, thus delaying sample shipment.
- **Improper, misspelled, or missing information on the shipper's declaration.** The carrier will most likely notice this as well and return the package to the shipper.

Contact FedEx with questions about dangerous goods shipments by calling 1-800-463-3339 and asking for a dangerous goods expert.

FIGURE 1

EXAMPLE OF A CORRECTLY MARKED AND LABELED DANGEROUS GOODS PACKAGE



Source: International Air Transport Association (IATA). 1997.

FIGURE 2

EXAMPLE OF A DANGEROUS GOODS AIRBILL

FedEx Dangerous Goods **Sender's Copy**
Airbill ATTAIN THIS COPY FOR YOUR RECORDS

1 From Please print and press hard.
Date **FILL IN** Sender's FedEx Account Number **1788-8014-4**
Sender's Name **FILL IN** Phone **312 856 8700**

Company **TETRA TECH EM INC**
Address **200 E RANDOLPH ST STE 4700**
City **CHICAGO** State **IL** Zip **60601**

2 Your first and last name
3 To
Recipient's Name
Company
Address
City
State
Zip

4 For HOLD at FedEx Location check here
☐ Hold at Location
☐ Hold at FedEx Location
For WEEKEND Delivery check here
☐ Saturday Delivery
☐ Sunday Delivery

5 Express Package Service Packages up to 68 lb.
☒ FedEx Priority Overnight
☐ FedEx Standard Overnight
☐ FedEx 2Day
☐ FedEx Express Saver

6 Express Freight Service Packages over 68 lb.
☐ FedEx 10 kg Freight
☐ FedEx 30 kg Freight
☐ FedEx 50 kg Freight

7 Signature Release Unavailable

8 Tracking Number **813350883058** **0204**

9 Transport Details
This shipment is within the
hazardous materials regulations
of the Department of Transportation
and is classified as
Hazardous Materials
Class **3** **UN 1993**
Amount of Dangerous Goods
Chicago
Amount of Dangerous Goods
City sending sample to

10 Nature and Quantity of Dangerous Goods
Proper Shipping Name
Class or Division
UN or LBN No.
Packing Group
Subsidiary Risk
Quantity and Type of Packaging
Packing Instructions
Authentication

11 Additional Handling Information
NAERG# 128 Attached.

12 I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name and are classified, packaged, marked, and labeled in accordance with applicable international and national governmental regulations.
Emergency Telephone Number Shipment for U.S. Origin or Destination
FILL IN

13 Signature of Shipper
ME, Environmental Scientist
200 E Randolph, Chicago, IL 60601
1/24/00

14 If acceptable for passenger aircraft this shipment contains radioactive materials intended for use in, or incident to, research, medical diagnosis, or treatment.

FIGURE 3

NAERG EMERGENCY RESPONSE INFORMATION
FOR FLAMMABLE LIQUIDS, N.O.S.

HAZARD	CAUTION
HAZARD <ul style="list-style-type: none">• EXTREMELY FLAMMABLE: Will be easily ignited by heat, sparks or flames.• Vapors may form explosive mixtures with air.• Vapors may travel to source of ignition and flashback.• Most vapors are heavier than air. They will spread along ground and collect in low or confined areas, basements, tunnels, etc.• Vapor explosion hazard exists. Confined or in vessels.• Some may polymerize if exposed to heat or in contact with a fire.• Runoff to sewer may create fire or explosion hazard.• Containers may explode when heated.• Many liquids are lighter than water.• Substances may be transported hot.	CAUTION: All these products have a very low flash point: use of water spray when fighting fire may be ineffective. Small Fire <ul style="list-style-type: none">• Dry chemical, CO₂, water spray or regular foam.Large Fire<ul style="list-style-type: none">• Water spray, fog or regular foam.• Do not use dry-chalk streams.• Move containers from fire area if you can do it without risk. Fire Involving Tanks or Containers Loaded <ul style="list-style-type: none">• Fight fire from maximum distance or use unmanned area bottom or master nozzle.• Cool containers with floating quantities of water until well after fire is out.• Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.• As tanks empty, some vapors may be seen.• For shippers fire, use unmanned hose nozzles or water cannons. If fire is responsible, withdraw from scene and let fire burn.
REACTIVITY <ul style="list-style-type: none">• Irritation or contact with moisture may irritate or burn skin and eyes.• Fumes may produce irritation, corrosion and/or toxic gases.• Vapors may cause dizziness or suffocation.• May react with oxidants to form toxic gases.	REACTIVITY <ul style="list-style-type: none">• ELIMINATE all ignition sources (no smoking, flames, sparks or flames in immediate area).• All equipment used when handling the product must be grounded.• Do not touch or walk through spilled material.• Stop work if you can do it without risk.• Prevent entry into sewers, vents, basements or confined areas.• A vapor accumulating there may be used to reduce vapors.• Report or clean with dry earth, sand or other non-combustible material and transfer to container.• Use clean non-sparking tools to collect absorbed material.
ENVIRONMENTAL HAZARD <ul style="list-style-type: none">• CALL Emergency Response Telephone Number on Shipping Paper first. If Shipping Paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.• Move up if or down area immediately for at least 250m (80 to 900 feet) in all directions.• Keep unauthorized personnel away.• Stay upwind.• Keep out of low areas.• Ventilate closed spaces before entering.	ENVIRONMENTAL HAZARD <ul style="list-style-type: none">• ELIMINATE all ignition sources (no smoking, flames, sparks or flames in immediate area).• All equipment used when handling the product must be grounded.• Do not touch or walk through spilled material.• Stop work if you can do it without risk.• Prevent entry into sewers, vents, basements or confined areas.• A vapor accumulating there may be used to reduce vapors.• Report or clean with dry earth, sand or other non-combustible material and transfer to container.• Use clean non-sparking tools to collect absorbed material.
SPILL/LEAK RESPONSE <ul style="list-style-type: none">• Small Spill<ul style="list-style-type: none">• Contain, absorb, remove or collect for at least 300 meters (1000 feet).Large Spill<ul style="list-style-type: none">• Contain, absorb, remove or collect for at least 300 meters (1000 feet).	SPILL/LEAK RESPONSE <ul style="list-style-type: none">• Small Spill<ul style="list-style-type: none">• Contain, absorb, remove or collect for at least 300 meters (1000 feet).Large Spill<ul style="list-style-type: none">• Contain, absorb, remove or collect for at least 300 meters (1000 feet).

Source: DOT and others. 1996.

TETRA TECH EM, INC.

MONITORING WELL SAMPLING SHEET

Monitoring Well No.: _____

Date: _____

Personnel: _____

Organic Vapor Concentration TOC: _____ ppm Breathing Zone: _____ ppm

Depth to Well Bottom: _____ ft **Well Volume:**

2-inch well =	water column x 0.163 gal/ft
3-inch well =	water column x 0.367 gal/ft

Depth to Water: _____ ft 4-inch well = water column x 0.652 gal/ft

Water Column: _____ ft Well Volume: _____ gal

[illegible]

Begin Purge: _____ Method of Purging ☐ Pump ☐ Bailer

End Purge: _____ Purged Dry? _____

Total Volume Purged: _____ How Measured? _____

QA/QC Sample Collected Here? ☐ Duplicate ☐ Matrix Spike ☐ Equip. Blank ☐ No QA/QC Sample

Date and Time of Sample Collection: _____ Sample Number (s): _____

Comments: _____



TETRA TECH EM INC.

SOIL BORING AND WELL INSTALLATION LOG

CTO:
Bldg./Site:
Project:

Boring Number:	Date Started/Completed:
Drilling Method:	Location Sketch:
Outer Diameter of Boring:	
Inner Diameter of Well Casing:	
Depth to Water (ft. bgs., date)	
Driller:	
Logged By:	

Depth (ft) bgs	Sample Number	Drive Interval/ Recovered Interval	Blow Count (per 6 inches)	Soil Boring _____ Lithologic Description	USCS Soil Symbol	Well Construction	QVM (ppm)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Depth (ft) bgs	Sample Number	Drive Interval/ Recovered Interval	Blow Count (per 6 inches)	Soil Boring _____ Lithologic Description	USCS Soil Symbol	Well Construction	OVM (ppm)
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							

APPENDIX D
PROJECT-REQUIRED REPORTING LIMITS

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION INORGANICS (METALS IN WATER) STATEMENT OF WORK REPORTING LIMITS
TO NWSBD CONCORD REGULATORY CRITERIA**

Analytes	Reporting Limit (µg/L)	Regulatory Criteria						Project Reporting Limit Below Criteria?
		Federal Primary MCL ⁵ (µg/L)	Federal Secondary MCL ⁶ (µg/L)	National Recommended Water Quality Criteria ⁴		EPA California Water Quality Criteria (California Toxics Rule) ⁸		Concord Water Screening Value ⁷ (µg/L)
				Freshwater (µg/L)	Saltwater (µg/L)	Freshwater (µg/L)	Saltwater (µg/L)	
Aluminum	30	--	50	--	--	--	NA	--
Antimony	2	6	--	--	--	150	36	36
Arsenic ¹	1	50	--	150	36	--	--	--
Barium	10	2,000	--	--	--	--	--	--
Beryllium	1	4	--	--	--	--	--	--
Cadmium	1	5	--	6.2	9.3	6.2	9.3	6.2
Calcium	5,000	--	--	--	--	554 ¹	NA	230.7 ¹
Chromium III	2	100	--	11	50	11 ¹	50 ¹	11
Chromium VI	2	--	--	--	--	--	--	--
Chromium	2	--	--	--	--	--	--	--
Cobalt	0.5	--	--	--	--	29.3 ¹	3.1	3.1
Copper	2	1,300g	1,000	5.2	3.1	5.2	--	--
Cyanide	1	200	--	--	--	--	--	--
Iron	100	--	300	--	--	10.9 ¹	18.61	8.1
Lead	1	15 ⁸	--	10.9 ¹	8.1	--	--	--
Magnesium	5,000	--	--	--	--	--	--	--
Manganese	0.5	--	50	--	--	--	--	--
Mercury	0.025 ²	2	--	0.77	0.84	--	0.025	0.025
Molybdenum	5	--	--	--	--	--	--	--
Nickel	1	--	--	168 ¹	8.2	168 ¹	7.1 ¹	8.2
Potassium	5,000	--	--	--	--	--	--	--
Selenium	5	50	--	4.6 ¹	71	5	NA	4.6
Silver	0.19	--	--	37.4 CMC	1.9 CMC	37.4 CMC	NA	1.9
Sodium	5,000	--	--	--	--	--	--	--
Thallium	1	2	--	--	--	--	--	--
Vanadium	1	--	--	--	--	328.4 ¹	74.8 ¹	81
Zinc	1	--	5,000	328.4 ¹	81	--	58 ⁴	81

COMPARISON OF EPA CONTRACT LABORATORY PROGRAM LOW CONCENTRATION INORGANICS (METALS IN WATER) STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA

Notes:

- Not available
- µg/L Microgram per liter
- ca Carcinogenic PRG
- CCC Criterion continuous concentration
- CLP Contract Laboratory Program
- CMC Criterion maximum concentration
- EPA U.S. Environmental Protection Agency
- MCL Maximum contaminant limit
- nc Noncarcinogenic PRG
- PCB Polychlorinated biphenyl
- PRG Preliminary remediation goal

Bolded values indicate that the regulatory criterion is less than the reporting limit. The listed PRGL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

^a Criteria taken from <http://www.epa.gov/Region9/waste/fund/prg/index.htm> (April, 2002)

^b Criteria taken from <http://www.epa.gov/EPA-WATER/2000/June/Day-21/w9534.htm> (April, 2002)

^c Concord Water Screening Values are based on the EPA National Water Quality Criteria (EPA 1998, 1999), California Toxics Rule, and the Bay Basin Plan Upstream of San Pablo Bay (RWQCB 1995).

^d Criteria are taken from <http://www.epa.gov/fedrgar/EPA-WATER/1998/December/Day-10/w30272.htm> (April, 2002); values are CCC unless otherwise indicated.

^e Criteria are taken from <http://www.epa.gov/OST/standards/ctn/index.html> (April, 2002); values are CCC unless otherwise indicated.

^f Tap water PRG for arsenic is based on a cancer endpoint

^g Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10 percent of tap water samples exceed the action level, water systems must take additional steps. For copper the action level is 1.3 milligrams per liter, and for lead, is 0.015 milligram per liter.

^h Mercury will be collected with "ultra-clean" sampling methods detailed in EPA method 1669 and will be analyzed by EPA Method 1631.

ⁱ Criterion is hardness dependent. This value corresponds to a total hardness of 400 mg/L as CaCO₃ in the water body.

^j This limit may be met as total chromium.

^k The 24-hour average concentration was used because no 4-day average was available.

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (SEMIVOLATILES IN WATER)
STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/L)	Regulatory Criteria		Project Reporting Limit Below Criterion?
		EPA Region 9 Tap Water PRG ^a (µg/L)	Federal Primary MCL ^b (µg/L)	
Benzaldehyde	5	3,649.99 nc	--	Yes
Phenol	5	21,899.52 nc	--	Yes
bis(2-Chloroethyl) ether	5	--	--	--
2-Chlorophenol	5	30.42 nc	--	Yes
2-Methylphenol	5	1,825.00 nc	--	Yes
2,2'-oxybis(1-Chloropropane)	5	--	--	--
Acetaphenone	5	0.04 nc	--	No
4-Methylphenol	5	182.50 nc	--	Yes
N-Nitroso-di-n-propylamine	5	0.01 ca	--	No
Hexachloroethane	5	4.80 ca ^c	--	No
Nitrobenzene	5	3.40 nc	--	No
Isophorone	5	70.77 ca	--	Yes
2-Nitrophenol	5	--	--	--
2,4-Dimethylphenol	5	730.00 nc	--	Yes
bis(2-Chloroethoxy) methane	5	--	--	--
2,4-Dichlorophenol	5	109.50 nc	--	Yes
Naphthalene	5	--	--	--
4-Chloroaniline	5	146.00 nc	--	Yes
Hexachlorobutadiene	5	0.86 ca ^f	--	No
Caprolactam	5	18,249.67 nc	--	Yes
4-Chloro-3-methylphenol	5	0.12 ca	--	No
2-Methylnaphthalene	5	--	--	--
Hexachlorocyclopentadiene	5	255.50 nc	50	Yes
2,4,6-Trichlorophenol	5	6.11 ca	--	Yes
2,4,5-Trichlorophenol	20	3,649.99 nc	--	Yes
1,1'-Biphenyl	5	304.17 nc	--	Yes
2-Chloronaphthalene	5	--	--	--
2-Nitroaniline	20	2.09 nc	--	No
Dimethylphthalate	5	364,866.82 nc	--	Yes
Acenaphthylenc	5	--	--	--
2,6-Dinitrotoluenc	5	36.50 nc	--	Yes
3-Nitroaniline	20	--	--	--
Accnaphthenc	5	--	--	--
2,4-Dinitrophenol	20	73.00 nc	--	Yes
4-Nitrophenol	20	292.00 nc	--	Yes
Dibenzofuran	5	24.33 nc	--	Yes
2,4-Dinitrotoluene	5	73.00 nc	--	Yes
Diethylphthalate	5	29,199.15 nc	--	Yes
4-Chlorophenyl-phenylether	5	--	--	--
Fluorene	5	--	--	--
4-Nitroaniline	20	--	--	--
4,6-Dinitro-2-methylphenol	20	--	--	--
N-Nitrosodiphenylamine	5	13.72 ca	--	Yes
4-Bromophcnyl-phenylether	5	--	--	--

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (SEMIVOLATILES IN WATER)
STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/L)	Regulatory Criteria		Project Reporting Limit Below Criterion?
		EPA Region 9 Tap Water PRG ^a (µg/L)	Federal Primary MCL ^b (µg/L)	
Hexachlorobenzene	5	0.04 ca	1	No
Atrazine	5	0.30 ca	3	No
Pentachlorophenol	5	0.56 ca	1	No
Phenanthrene	5	--	--	--
Anthracene	5	--	--	--
Carbazole	--	3.36 ca	--	No
Di-n-butylphthalate	5	--	--	--
Fluoranthene	5	--	--	--
Pyrene	5	--	--	--
Butylbenzylphthalate	5	7,299.95 nc	--	Yes
3,3'-Dichlorobenzidine	5	0.15 ca	--	No
Benzo(a)anthracene	5	--	--	--
Chrysene	5	--	--	--
bis-(2-Ethylhexyl)phthalate	5	--	--	--
Di-n-octylphthalate	5	--	--	--
Benzo(b)fluoranthene	5	--	--	--
Benzo(k)fluoranthene	5	--	--	--
Benzo(a)pyrene	5	--	--	--
Indeno(1,2,3-cd)pyrene	5	--	--	--
Dibenzo(a,h)anthracene	5	--	--	--
Benzo(g,h,i)perylene	5	--	--	--
1,2,4,5-Tetrachlorobenzene	5	10.95 nc	--	Yes

Notes:

- = Not available
- µg/L = Microgram per liter
- ca = Carcinogenic PRG
- CCC = Criterion continuous concentration
- CLP = Contract Laboratory Program
- CMC = Criterion maximum concentration
- MCL = Maximum contaminant limit
- nc = Noncarcinogenic PRG
- PCB = Polychlorinated biphenyl
- PRG = Preliminary remediation goal

The listed PRRL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

^a Criteria are taken from <http://www.epa.gov/Region9/waste/sfund/prg/index.htm> (April, 2002)

^b Criteria are taken from <http://www.epa.gov/EPA-WATER/2000/June/Day-21/w9534.htm> (April WATER/1998/December/Day-10/w30272.htm (April, 2002); values are

^c CCC unless otherwise indicated.

^d Criteria are taken from <http://www.epa.gov/OST/standards/ctrindex.html> (April, 2002); values are

^e Where: nc < 10 x ca

^f Where: nc < 100 x ca

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (PESTICIDES/PCBs IN WATER)
STATEMENT OF WORK REPORTING LIMITS TO NWSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/L)	Regulatory Criteria							Project Reporting Limit Below Criterion?	
		Tap Water PRG ^a (µg/L)	Federal Primary MCL ^b (µg/L)	EPA National Recommended Water Quality Criteria ^c		EPA State of California Water Quality Criteria (California Toxics Rule ^d)				
				Freshwater (µg/L)	Saltwater (µg/L)	Freshwater (µg/L)	Saltwater (µg/L)	Saltwater COC (µg/L)		
alpha-BHC	0.010	--	--	--	--	--	--	--	--	--
beta-BHC	0.010	--	--	--	--	--	--	--	--	--
delta-BHC	0.010	--	--	--	--	--	--	--	--	--
gamma-BHC (Lindane)	0.010	--	--	0.95 CMC	0.16 CMC	0.16 CMC	0.95 CMC	0.16 CMC	0.16 CMC	Yes
Heptachlor	0.004	0.015 ca	0.40	0.0038	0.0036	0.0038	0.0038	0.0036	0.0036	Yes
Aldrin	0.010	0.004 ca	--	3.00 CMC	1.30 CMC	3 CMC	3 CMC	1.3 CMC	1.3 CMC	No
Heptachlor epoxide	0.004	--	0.20	0.0038	0.0036	0.0038	0.0038	0.0036	0.0036	Yes
Endosulfan I ^e	0.010	219,000 nc	--	--	--	--	--	--	--	Yes
Dieldrin	0.002	0.004 ca	--	0.0560	0.0019	0.0019	0.056	0.0019	0.0019	Yes
4,4'-DDE ^f	0.020	0.198 ca	--	--	--	--	--	--	--	Yes
Endrin	0.002	10,950 nc	2.00	0.036	0.0023	0.0023	0.036	0.023	0.023	Yes
Endosulfan II	0.020	--	--	--	--	--	--	--	--	--
4,4'-DDD ^g	0.020	0.280 ca	--	--	--	--	--	--	--	Yes
Endosulfan sulfate	0.020	--	--	--	--	--	--	--	--	--
4,4'-DDT ^h	0.001	0.198 ca ⁱ	--	0.001	0.001	0.001	0.001	0.001	0.001	Yes
Methoxychlor	0.030	182,500 nc	40.00	--	--	--	--	--	--	Yes
Endrin ketone	0.020	--	--	--	--	--	--	--	--	--
Endrin aldehyde	0.020	--	--	--	--	--	--	--	--	--
alpha-Chlordane ^j	0.010	0.192 ca ⁱ	2.00	0.0043	0.004	0.004	0.0043	0.004	0.004	No
gamma-Chlordane	0.010	--	--	--	--	--	--	--	--	--
Toxaphene	0.000	0.061 ca	3.00	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	Yes
Aroclor-1016	0.200	0.960 ca ^k	--	--	--	--	--	--	--	Yes
Aroclor-1221	0.400	0.034 ca	--	--	--	--	--	--	--	No
Aroclor-1232	0.200	0.034 ca	--	--	--	--	--	--	--	No
Aroclor-1242	0.200	0.034 ca	--	--	--	--	--	--	--	No
Aroclor-1248	0.200	0.034 ca	--	--	--	--	--	--	--	No
Aroclor-1254	0.200	0.034 ca ⁱ	--	--	--	--	--	--	--	No

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (PESTICIDES/PCBs IN WATER)
STATEMENT OF WORK REPORTING LIMITS TO NWSBD CONCORD REGULATORY CRITERIA**

		Regulatory Criteria						Project Reporting Limit Below Criterion?	
		Reporting Limit (µg/L)	Tap Water PRG ^a (µg/L)	Federal Primary MCL ^b (µg/L)	EPA National Recommended Water Quality Criteria ^c		EPA State of California Water Quality Criteria (California Toxics Rule ^d)		
					Freshwater (µg/L)	Saltwater (µg/L)	Freshwater (µg/L)		Saltwater CCC (µg/L)
Analyte									
Aroclor-1260	0.200		0.034 ca	--	--	--	--	--	No
Total PCBs ^e	1.600	--		0.50	0.014	0.03	0.014	0.03	No

Notes:

- = Not available
- µg/L = Microgram per liter
- ca = Carcinogenic PRG
- CCC = Criterion continuous concentration
- CLP = Contract Laboratory Program
- CMC = Criterion maximum concentration
- EPA = U.S. Environmental Protection Agency
- MCL = Maximum contaminant limit
- nc = Noncarcinogenic PRG
- PCB = Polychlorinated biphenyl
- PRG = Preliminary remediation goal

Bolded values indicate that the regulatory criterion is less than the reporting limit. The listed PRRL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

- ^a Criteria are taken from <http://www.epa.gov/Region9/waste/sfund/prg/index.htm> (April, 2002)
- ^b Criteria are taken from <http://www.epa.gov/EPA-WATER/2000/June/Day-21/w9534.htm> (April, 2002)
- ^c Criteria are taken from <http://www.epa.gov/fedrgstr/EPA-WATER/1998/December/Day-10/w30272.htm> (April, 2002); values are CCC unless otherwise indicated.
- ^d Criteria are taken from <http://www.epa.gov/OST/standards/ctrindex.html> (April, 2002); values are CCC unless otherwise indicated.
- ^e Regulatory criteria for endosulfan was used
- ^f Regulatory criteria for DDE was used
- ^g Regulatory criteria for DDD was used
- ^h Regulatory criteria for DDT was used
- ⁱ Where: nc < 100 x ca
- ^j Regulatory criteria for chlordane used
- ^k Where: nc < 10 x ca
- ^l Sum of individual Aroclor reporting limits

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (HALOGENATED VOLATILES IN WATER)
STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/L)	Regulatory Criteria		Project Reporting Limit Below Criterion?
		EPA Region 9 Tap Water PRG ^a (µg/L)	Federal Primary MCL ^b (µg/L)	
1,1,1,2-Tetrachloroethane	0.5	0.43 ca	--	No
1,1,1-Trichloroethane	0.5	540.74 nc	--	Yes
1,1,2,2-Tetrachloroethane	0.5	0.06 ca	--	No
1,1,2-Trichloro-1,2,2-trifluoroethane	0.5	59,179.86 nc	--	Yes
1,1,2-Trichloroethane	0.5	0.20 ca	--	No
1,1,2-Trichlorotrifluoroethane ^c	0.5	59,179.86 nc	--	Yes
1,1-Dichloroethane	0.5	811.11 nc	--	Yes
1,1-Dichloroethene	0.5	0.05 ca	--	No
1,2-Dibromomethane	0.5	0.00 ca	--	No
1,2-Dichlorobenzene	0.5	370.14 nc	--	Yes
1,2-Dichlorobenzene	0.5	--	--	--
1,2-Dichloroethane	0.5	0.12 ca ⁱ	--	No
1,2-Dichloromethene (total)	0.5	60.83 nc	--	Yes
1,2-Dichloropropane	0.5	0.16 ca ⁱ	5.00	No
1,3-Dichlorobenzene	0.5	5.48 nc	--	Yes
1,3-Dichloropropene	0.5	0.40 ca	--	No
1,4-Dichlorobenzene	0.5	0.50 ca	--	Yes
1-Chlorohexane	0.5	--	--	--
2-Chloroethyl vinyl ether	0.5	--	--	--
Benzyl chloride	0.5	0.07 ca	--	No
Bromobenzene	0.5	20.30 nc	--	Yes
Bromodichloromethane	0.5	0.18 ca	--	No
Bromoform	0.5	8.51 ca [*]	--	Yes
Bromomethane	0.5	8.66 nc	--	Yes
Carbon tetrachloride	0.5	0.17 ca ⁱ	5.00	No
Chlorobenzene	0.5	106.07 nc	--	Yes
Chloroethane	0.5	4.64 ca	--	Yes
Chloroform	0.5	0.16 ca ⁱ	--	No
Chloromethane	0.5	1.51 ca	--	Yes
Chlorotoluenes	0.5	121.67 nc	--	Yes
cis-1,2-Dichloroethene	0.5	60.83 nc	70.00	Yes
cis-1,3-Dichloropropene	0.5	0.40 ca	--	No
Dibromochloromethane	0.5	0.13 ca	--	No
Dibromomethane	0.5	--	--	--
Dichlorodifluoromethane	0.5	394.59 nc	--	Yes
Methylene chloride	0.5	4.28 ca	--	Yes
Tetrachloroethene	0.5	1.08 ca	5.00	Yes
Trans-1,2-dichloroethene	0.5	--	--	--
Trans-1,3-dichloropropene	0.5	--	--	--
Trichloroethene	0.5	1.64 ca ⁱ	5.00	Yes
Trichlorofluoromethane	0.5	1,288.24 nc	--	Yes
Trichloropropane	0.5	30.42 nc	--	Yes
Trichloropropane	0.5	0.00 ca	--	No
Vinyl chloride	0.5	0.04 ca	2.00	No

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (HALOGENATED VOLATILES IN WATER)
STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA**

Notes:

--	=	Not available
µg/L	=	Microgram per liter
ca	=	Carcinogenic PRG
CATR	=	California Toxic Rule
CCC	=	Criterion continuous concentration
CLP	=	Contract Laboratory Program
CMC	=	Criterion maximum concentration
EPA	=	U.S. Environmental Protection Agency
MCL	=	Maximum contaminant limit
nc	=	Noncarcinogenic PRG
NRWQC	=	National Recommended Water Quality Criteria
PRG	=	Preliminary remediation goal

listed PRRL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable

- a Criteria are taken from <http://www.epa.gov/Region9/waste/sfund/prg/index.htm> (April, 2002)
- b Criteria are taken from <http://www.epa.gov/EPA-WATER/2000/June/Day-21/w9534.htm> (April, 2002)
- c Criteria are taken from <http://www.epa.gov/fedrgstr/EPA-WATER/1998/December/Day-10/w30272.htm>
- d Criteria are taken from <http://www.epa.gov/OST/standards/ctrindex.html> (April, 2002); values are CCC
- e Regulatory criteria for 1,1,2-trichloro-1,2,2-trifluoroethane was used
- f MCL regulatory criterion for o-dichlorobenzene was used
- g MCL regulatory criterion for p-dichlorobenzene was used
- h Regulatory criteria for 1,2-dichloroethylene (cis) was used
- i Where: $nc < 100 \times ca$
- j Where: $nc < 10 \times ca$

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (CHLORINATED HERBICIDES IN WATER)
STATEMENT OF WORK REPORTING LIMITS TO NWSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/L)	Regulatory Criteria						Project Reporting Limit Below Criterion?
		EPA Region 9 Tap Water PRG ^a (µg/L)	Federal Primary MCL ^b (µg/L)	EPA National Recommended Water Quality Criteria ^c		EPA State of California Water Quality Criteria (California Toxics Rule) ^d		
				Freshwater (µg/L)	Saltwater (µg/L)	Freshwater (µg/L)	Saltwater (µg/L)	
2,4,5-TP (SILVEX)	0.1	--	50	--	--	--	--	Yes
2,4-D	1	365.00 nc	70	--	--	--	--	Yes
2,4-DB	1	292.00 nc	--	--	--	--	--	Yes
2,4-Dichlorophenoxyacetic acid	5	--	--	--	--	--	--	--
2-Sec-butyl-4,6-dinitrophenol	5	--	--	--	--	--	--	--
3,5-Dichlorobenzoic acid	5	--	--	--	--	--	--	--
Dalapon	2.5	1,095.00 nc	200	--	--	--	--	Yes
Dicamba	0.1	1,095.00 nc	--	--	--	--	--	Yes
Dichloroprop	1	--	--	--	--	--	--	--
Dinoseb	0.5	36.50 nc	7	--	--	--	--	Yes
DNOC	5	--	--	--	--	--	--	--
MCPA	100	--	--	--	--	--	--	--
MCPP (MECOPROP)	100	--	--	--	--	--	--	--
Pentachlorophenol	5	0.56 ca	1	15	7.9	15	7.9	No
Picloram	5	2,554.99 nc	500	--	--	--	--	Yes

Notes:

-- = Not available
 µg/L = Microgram per liter
 ca = Carcinogenic PRG
 CATR = California Toxic Rule
 CCC = Criterion continuous concentration
 CLP = Contract Laboratory Program

CMC = Criterion maximum concentration
 EPA = U.S. Environmental Protection Agency
 nc = Noncarcinogenic PRG
 MCL = Maximum contaminant limit
 NRWQC = National Recommended Water Quality Criteria
 PRG = Preliminary remediation goal

Bolded values indicate that the regulatory criterion is less than the reporting limit. The listed PRRL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

^a Criteria are taken from <http://www.epa.gov/Region9/waste/stfund/prg/index.htm> (April, 2002)

^b Criteria are taken from <http://www.epa.gov/EPA-WATER/2000/June/Day-21/w-9534.htm> (April, 2002)

^c Criteria are taken from <http://www.epa.gov/fedrgstr/EPA-WATER/1998/December/Day-10/w30272.htm> (April, 2002); values are CCC unless otherwise indicated.

^d Criteria are taken from <http://www.epa.gov/OST/standards/critindex.html> (April, 2002); values are CCC unless otherwise indicated.

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION INORGANICS (METALS IN SOIL)
STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit	Industrial Soil PRG ^c	Project Reporting Limit Below Criterion?
	mg/kg	(mg/kg)	
Aluminum	10	100,000 max	Yes
Antimony	1	818 nc	Yes
Arsenic	0.39	439 nc	Yes
Arsenic	0.39	2.73 ca	Yes
Barium	4	100,000 max	Yes
Beryllium	0.2	2,242 ca ^b	Yes
Cadmium	0.4	809 nc	Yes
Cadmium	0.4	--	--
Calcium	1,000	--	--
Chromium	1	448 ca	Yes
Chromium III	1	100,000 max	Yes
Chromium VI	1	64 ca	Yes
Cobalt	1	100,000 max	Yes
Copper	0.8	75,908 nc	Yes
Cyanide	1,000	35 nc	Yes
Iron	20,000	100,000 max	Yes
Lead	2,000	750 nc	Yes
Magnesium	1,000	--	Yes
Manganese	2,000	32,250 nc	Yes
Mercury	0.020	613 nc	Yes
Molybdenum	1,000	10,220 nc	Yes
Nickel	1,600	40,877 nc	Yes
Nickel ^c	1,600	--	--
Potassium	1,000	--	--
Selenium	7,000	10,220 nc	Yes
Silver	0.4	10,220 nc	Yes
Sodium	1,000	--	--
Thallium	0.4	135 nc	Yes
Vanadium	2,000	14,308 nc	Yes
Zinc	2,000	100,000 max	Yes

Notes:

- = Not available
- mg/kg = Milligram per kilogram
- ca = Carcinogenic PRG
- max = Ceiling limit
- nc = Noncarcinogenic PRG
- PRG = Preliminary remediation goal

Bolded values indicate that reporting limit exceeds one or more regulatory criteria. The listed PRRL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

^a Where: nc < 100 x ca

^b Where: nc < 10 x ca

^c Criteria are taken from <http://www.epa.gov/Region9/waste/sfund/prg/index.htm> (April, 2002)

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (SEMIVOLATILES IN SOIL)
STATEMENT OF WORK REPORTING LIMITS TO NWSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/kg)	Industrial Soil PRG ^e (µg/kg)	Project Reporting Limit Below Criterion?
Benzaldehyde	330	88,091,907 nc	Yes
Phenol	330	100,000,000 max	Yes
bis(2-Chloroethyl) ether	330	--	--
2-Chlorophenol	330	241,335 nc	Yes
2-Methylphenol	330	44,045,954 nc	Yes
2,2'-oxybis(1-Chloropropane)	330	--	--
Acetaphenone	330	1,614 nc	Yes
4-Methylphenol	330	4,404,595 nc	Yes
N-Nitroso-di-n-propylamine	69	352 ca	Yes
Hexachloroethane	330	176,184 ca ^a	Yes
Nitrobenzene	330	114,463 nc	Yes
Isophorone	330	2,596,393 b	Yes
2-Nitrophenol	330	--	--
2,4-Dimethylphenol	330	17,618,381 nc	Yes
bis(2-Chloroethoxy) methane	210	--	--
2,4-Dichlorophenol	330	2,642,757 nc	Yes
Naphthalene	330	--	--
4-Chloroaniline	330	3,523,676 nc	Yes
Hexachlorobutadiene	330	31,623 ca ^a	Yes
Caprolactam	330	100,000,000 max	Yes
4-Chloro-3-methylphenol	330	4,253 ca	Yes
2-Methylnaphthalene	330	--	--
Hexachlorocyclopentadiene	330	5,896,843 nc	Yes
2,4,6-Trichlorophenol	330	224,234 ca	Yes
2,4,5-Trichlorophenol	830	88,091,907 nc	Yes
1,1'-Biphenyl	330	350,000 sat	Yes
2-Chloronaphthalene	330	1,000	Yes
2-Nitroaniline	830	50,338 nc	Yes
Dimethylphthalate	330	100,000,000 max	Yes
Acenaphthylene	330	--	--

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (SEMI-VOLATILES IN SOIL)
STATEMENT OF WORK REPORTING LIMITS TO NWSBDD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/kg)	Industrial Soil PRG ^c (µg/kg)	Project Reporting Limit Below Criterion?
2,6-Dinitrotoluene	330	880,919 nc	Yes
3-Nitroaniline	830	--	--
Acenaphthene	330	--	--
2,4-Dinitrophenol	830	1,761,838 nc	Yes
4-Nitrophenol	830	7,047,353 nc	Yes
Dibenzofuran	330	5,062,805 nc	Yes
2,4-Dinitrotoluene	330	1,761,838 nc	Yes
Diethylphthalate	330	100,000,000 max	Yes
4-Chlorophenyl-phenylether	330	--	--
Fluorene	330	--	--
4-Nitroaniline	830	--	--
4,6-Dinitro-2-methylphenol	830	--	--
N-Nitrosodiphenylamine	330	503,382 ca	Yes
4-Bromophenyl-phenylether	330	--	--
Hexachlorobenzene	300	1,542 ca	Yes
Atrazine	330	11,111 ca	Yes
Pentachlorophenol	830	11,091 ca	Yes
Phenanthrene	330	--	--
Anthracene	330	--	--
Carbazole	330	123,329 ca	Yes
Di-n-butylphthalate	330	--	--
Fluoranthene	330	--	--
Pyrene	330	--	--
Butylbenzylphthalate	330	100,000,000 max	Yes
3,3'-Dichlorobenzidine	330	5,481 ca	Yes
Benzo(a)anthracene	330	--	--
Chrysene	330	--	--
bis-(2-Ethylhexyl)phthalate	330	--	--
Di-n-octylphthalate	330	--	--
Benzo(b)fluoranthene	330	--	--

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (SEMI-VOLATILES IN SOIL)
STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/kg)	Industrial Soil PRG ^c (µg/kg)	Project Reporting Limit Below Criterion?
Benzo(k)fluoranthene	330	--	--
Benzo(a)pyrene	62	--	--
Indeno(1,2,3-cd)pyrene	330	--	--
Dibenzo(a,h)anthracene	62	--	--
Benzo(g,h,i)perylene	330	--	--
1,2,4,5-Tetrachlorobenzene	--	264,276 nc	--

Notes:

-- = Not available
 µg/kg = Microgram per kilogram
 ca = Carcinogenic PRG
 max = Ceiling limit
 nc = Noncarcinogenic PRG
 PRG = Preliminary remediation goal
 sat = Soil saturation

Bolded values indicate that reporting limit exceeds one or more regulatory criteria. The listed PRRL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

^a Where: nc <100 x ca

^b Where: nc <10 x ca

^c Criteria are taken from <http://www.epa.gov/Region9/waste/sfund/prg/index.htm> (April, 2002)

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (PESTICIDES/PCBs IN SOIL)
STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/kg)	Industrial Soil PRG ^b (µg/kg)	Project Reporting Limit Below Criterion?
alpha-BHC	1.7	--	--
beta-BHC	1.7	--	--
delta-BHC	1.7	--	--
gamma-BHC (Lindane)	1.7	--	--
Heptachlor	1.7	548.13 ca	Yes
Aldrin	1.7	145.09 ca	Yes
Heptachlor epoxide	1.7	--	--
Endosulfan I ^b	1.7	5,285,514.42 nc	Yes
Dieldrin	3.3	154.16 ca	Yes
4,4'-DDE ^c	3.3	12,055.36 ca	Yes
Endrin	3.3	264,275.72 nc	Yes
Endosulfan II	3.3	--	--
4,4'-DDD ^d	3.3	17,078.42 ca	Yes
Endosulfan sulfate	3.3	--	--
4,4'-DDT ^e	3.3	12,055.36 ca ^a	Yes
Methoxychlor	17	4,404,595.35 nc	Yes
Endrin ketone	3.3	--	--
Endrin aldehyde	3.3	--	--
alpha-Chlordane ^f	1.7	10,699.44 ca ^a	Yes
gamma-Chlordane	1.7	--	--
Toxaphene	170	2,242.33 ca	Yes
Aroclor-1016	33	28,704.80 ca**	Yes
Aroclor-1221	67	1,004.67 ca	Yes
Aroclor-1232	33	1,004.67 ca	Yes
Aroclor-1242	33	1,004.67 ca	Yes
Aroclor-1248	33	1,004.67 ca	Yes
Aroclor-1254	33	1,004.67 ca ^a	Yes
Aroclor-1260	33	1,004.67 ca	Yes

Notes:

- = Not available
- µg/kg = Microgram per kilogram
- ca = Carcinogenic PRG
- CCC = Criterion continuous concentration
- CLP = Contract Laboratory Program
- CMC = Criterion maximum concentration
- MCL = Maximum contaminant limit
- nc = Noncarcinogenic PRG
- PRG = Preliminary remediation goal

Bolded values indicate that the regulatory criterion is less than the reporting limit. The listed PRRL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

^a Where: nc <10 x ca

^b Regulatory criteria for endosulfan was used

^c Regulatory criteria for DDE was used

^d Regulatory criteria for DDD was used

^e Regulatory criteria for DDT was used

^f Regulatory criteria for chlordane used

^g Where: nc <100 x ca

^h Criteria are taken from <http://www.epa.gov/Region9/waste/sfund/prg/index.htm> (April, 2002)

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (HALOGENATED VOLATILES IN SOIL)
STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/kg)	Industrial Soil PRG ^c (µg/kg)	Project Reporting Limit Below Criterion?
1,1,1,2-Tetrachloroethane	5	7,036.11 ca	Yes
1,1,1-Trichloroethane	5	1,400,000.00 sat	Yes
1,1,2,2-Tetrachloroethane	5	898.24 ca	Yes
1,1,2-Trichloro-1,2,2-trifluoroethane	5	5,600,000.00 sat	Yes
1,1,2-Trichloroethane	5	1,901.55 ca ^a	Yes
1,1,2-Trichlorotrifluoroethane	5	5,600,000.00 sat	Yes
1,1-Dichloroethane	5	2,061,342.61 nc	Yes
1,1-Dichloroethene	5	118.70 ca	Yes
1,2-Dibromoethane	5	48.33 ca ^a	Yes
1,2-Dichlorobenzene	5	370,000.00 sat	Yes
1,2-Dichloroethane	5	764.81 ca ^a	Yes
1,2-Dichloroethene (total)	5	147,355.84 nc	Yes
1,2-Dichloropropane	5	767.76 ca ^a	Yes
1,3-Dichlorobenzene	5	51,755.44 nc	Yes
1,3-Dichloropropene	5	1,613.83 ca	Yes
1,4-Dichlorobenzene	5	8,128.69 ca	Yes
1-Chlorohexane	5	--	--
2-Chloroethyl vinyl ether	5	--	--
Benzyl chloride	5	2,310.08 ca	Yes
Bromobenzene	5	92,359.75 nc	Yes
Bromodichloromethane	5	2,357.29 ca	Yes
Bromoform	5	312,245.45 ca ^a	Yes
Bromomethane	5	13,137.84 nc	Yes
Carbon tetrachloride	5	529.26 ca ^a	Yes
Chlorobenzene	5	542,926.75 nc	Yes
Chloroethane	5	6,506.87 ca	Yes
Chloroform	5	521.01 ca ^b	Yes
Chloromethane	5	2,661.83 ca	Yes
Chlorotoluenes	5	567,788.52 nc	Yes
cis-1,2-Dichloroethene	5	147,355.84 nc	Yes

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (HALOGENATED VOLATILES IN SOIL)
STATEMENT OF WORK REPORTING LIMITS TO NWSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/kg)	Industrial Soil PRG ^c (µg/kg)	Project Reporting Limit Below Criterion?
cis-1,3-Dichloropropene	5	1,613.83 ca	Yes
Dibromochloromethane	5	2,653.77 ca	Yes
Dibromomethane	5	--	--
Dichlorodifluoromethane	5	308,290.57 nc	Yes
Methylene chloride	5	20,526.15 ca	Yes
Tetrachloroethene	5	18,666.92 ca ^a	Yes
Trans-1,2-dichloroethene	5	--	--
Trans-1,3-dichloropropene	5	--	--
Trichloroethene	5	6,116.23 ca ^a	Yes
Trichlorofluoromethane	5	2,000,000.00 sat	Yes
Trichloropropane	5	51,002.16 nc	Yes
Trichloropropane	5	3.09 ca	No
Vinyl chloride (child/adult)	--	--	--
Vinyl chloride (adult)	--	830.00 ca	--

Notes:

- = Not available
- µg/kg = Microgram per kilogram
- ca = Carcinogenic PRG
- EPA = U.S. Environmental Protection Agency
- MCL = Maximum contaminant limit
- nc = Noncarcinogenic PRG
- PRG = Preliminary remediation goal
- sat = Soil saturation

Bolded values indicate that the regulatory criterion is less than the reporting limit. The listed PRRL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

^a Where: nc <10 x ca

^b Where: nc <100 x ca

^c Criteria are taken from <http://www.epa.gov/Region9/waste/sfund/prg/index.htm> (April, 2002)

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
LOW CONCENTRATION ORGANICS (CHLORINATED HERBICIDES IN SOIL)
STATEMENT OF WORK REPORTING LIMITS TO NWSSBD CONCORD REGULATORY CRITERIA**

Analyte	Reporting Limit (µg/kg)	Industrial Soil		Project Reporting Limit Below Criterion?
		PRG ^a	(µg/kg)	
2,4,5-TP (silvex)	2	--	--	--
2,4-D	20	12,310,999	nc	Yes
2,4-DB	20	7,047,353	nc	Yes
2,4-Dichlorophenoxyacetic acid	160	--	--	--
2-Sec-butyl-4,6-dinitrophenol	160	--	--	--
3,5-Dichlorobenzoic acid	160	--	--	--
Dalapon	50	26,427,572	nc	Yes
Dicamba	160	26,427,572	nc	Yes
Dichloroprop	160	--	--	--
Dinoseb	160	880,919	nc	Yes
DNOC	160	--	--	--
MCPA	2,000	--	--	--
MCPP (mecoprop)	2,000	--	--	--
Pentachlorophenol	160	11,091	ca	Yes
Picloram	160	61,664,335	nc	Yes

Notes:

-- = Not available
 µg/kg = Microgram per kilogram
 ca = Carcinogenic PRG
 EPA = U.S. Environmental Protection Agency
 nc = Noncarcinogenic PRG
 PRG = Preliminary remediation goal

Bolded values indicate that the regulatory criterion is less than the reporting limit. The listed PRRL reflects the maximum sensitivity of current, routinely, used analytical methods. The listed PRRL will be used as the project screening criteria unless reasonable grounds are established for pursuing non-routine methods.

^a Criteria are taken from <http://www.epa.gov/Region9/waste/sfund/prg/index.htm> (April, 2002)

**COMPARISON OF EPA CONTRACT LABORATORY PROGRAM
FLUORIDE REPORTING LIMITS
TO NWSSB CONCORD REGULATORY CRITERIA**

Analyte	Soil		Water		
	Reporting Limit	Industrial Soil PRG ^a	Reporting Limit	Tap Water PRG ^a	Federal Primary MCL ^b
	(mg/kg)	(mg/kg)	(µg/L)	(µg/L)	(µg/L)
Fluoride	2.5	53,000	0.25	2.2	4

^a Criteria taken from <http://www.epa.gov/Region9/waste/sfund/prg/index.htm> (April, 2002)

^b Criteria taken from <http://www.epa.gov/EPA-WATER/2000/June/Day-21/w9534.htm> (April, 2002)

APPENDIX E
APPROVED LABORATORIES

APPENDIX E

TETRA TECH EM INC. LABORATORY BASIC ORDER AGREEMENT LIST March 7, 2001

Applied Physics and Chemistry Laboratory

Lab Address: 13760 Magnolia Avenue
Chino, CA 91710
POC: Dan Dischner/Eric Wendland
Phone: (909) 590-1828 X203/X104
Fax: (909) 590-1498
Business Size: Small disadvantaged business
E-mail: marketing@apclab.com

Columbia Analytical Services

Lab Address: 5090 Caterpillar Road
Redding, CA 96003
POC: Karen Sellers/Howard Boorse
Phone: (530) 244-5262 / (360) 577-7222
Fax: (530) 244-4109
Business Size: Large business
E-mail: Lkennedy@kelso.caslab.com

Curtis and Tompkins, Ltd

Lab Address: 2323 Fifth Street
Berkeley, CA 94710
POC: Anna Paillo/Mike Pearl
Phone: (510) 486-0925 X103/ X108
Fax: (510) 486-0532
Business Size: Small business
E-mail: mikep@ctberk.com

EMAX Laboratories Inc.

Lab Address: 1835 205th Street
Torrance, CA 90501
POC: Ye Myint/Jim Carter
Phone: (310) 618-8889 X121/X105
Fax: (310) 618-0818
Business Size: Small disadvantaged/woman-owned business
E-mail: Ymyint@emaxlabs.com

Laucks Laboratories

Lab Address: 940 S. Harney Street
Seattle, WA 98108
POC: Mike Owens/Kathy Kreps
Phone: (206) 767-5060
Fax: (206) 767-5063
Business Size: Small business
E-mail: KathyK@lauckslabs.com

APPENDIX F

EPA METHOD 1669: SAMPLING AMBIENT WATER FOR DETERMINATION OF TRACE METALS AT EPA WATER QUALITY CRITERIA LEVELS

Method 1669

**Sampling Ambient Water for Trace Metals at EPA Water Quality
Criteria Levels**

July 1996

**U.S. Environmental Protection Agency
Office of Water
Engineering and Analysis Division (4303)
401 M Street S.W.
Washington, D.C. 20460**

Acknowledgements

This sampling method was prepared under the direction of William A. Telliard of the Engineering and Analysis Division (EAD) within the U.S. Environmental Agency's (EPA's) Office of Science and Technology (OST). This sampling method was prepared under EPA Contract 68-C3-0337 by the DynCorp Environmental Programs Division, with assistance from Interface, Inc.

The following researchers contributed to the philosophy behind this sampling method. Their contribution is gratefully acknowledged:

Shier Berman, National Research Council, Ottawa, Ontario, Canada;
Nicholas Bloom, Frontier Geosciences Inc, Seattle, Washington;
Eric Crecelius, Battelle Marine Sciences Laboratory, Sequim, Washington;
Russell Flegal, University of California/Santa Cruz, California;
Gary Gill, Texas A&M University at Galveston, Texas;
Carlton Hunt and Dion Lewis, Battelle Ocean Sciences, Duxbury, Massachusetts;
Carl Watras, Wisconsin Department of Natural Resources, Boulder Junction, Wisconsin

Additional support was provided by Ted Martin of the EPA Office of Research and Development's Environmental Monitoring Systems Laboratory in Cincinnati, Ohio and by Arthur Horowitz of the U.S. Geological Survey.

This version of the method was prepared after observations of sampling teams from the University of California at Santa Cruz, the Wisconsin Department of Natural Resources, the U.S. Geological Survey, and Battelle Ocean Sciences. The assistance of personnel demonstrating the sampling techniques used by the institutions is gratefully acknowledged.

Disclaimer

This sampling method has been reviewed and approved for publication by the Analytical Methods Staff within the Engineering and Analysis Division of the U.S. Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Further Information

For further information, contact:

W.A. Telliard
Engineering and Analysis Division (4303)
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460
Phone: 202/260*7134
Fax: 202/260*7185

Introduction

This sampling method was designed to support water quality monitoring programs authorized under the Clean Water Act. Section 304(a) of the Clean Water Act requires EPA to publish water quality criteria that reflect the latest scientific knowledge concerning the physical fate (e.g., concentration and dispersal) of pollutants, the effects of pollutants on ecological and human health, and the effect of pollutants on biological community diversity, productivity, and stability.

Section 303 of the Clean Water Act requires states to set a water quality standard for each body of water within its boundaries. A state water quality standard consists of a designated use or uses of a waterbody or a segment of a waterbody, the water quality criteria that are necessary to protect the designated use or uses, and an antidegradation policy. These water quality standards serve two purposes: (1) they establish the water quality goals for a specific waterbody, and (2) they are the basis for establishing water quality-based treatment controls and strategies beyond the technology-based controls required by Sections 301(b) and 306 of the Clean Water Act.

In defining water quality standards, the state may use narrative criteria, numeric criteria, or both. However, the 1987 amendments to the Clean Water Act required states to adopt numeric criteria for toxic pollutants (designated in Section 307(a) of the Act) based on EPA Section 304(a) criteria or other scientific data, when the discharge or presence of those toxic pollutants could reasonably be expected to interfere with designated uses.

In some cases, these water quality criteria are as much as 280 times lower than those achievable using existing EPA methods and required to support technology-based permits. Therefore, this sampling method, and the analytical methods referenced in Table 1 of this document, were developed by EPA to specifically address state needs for measuring toxic metals at water quality criteria levels, when such measurements are necessary to protect designated uses in state water quality standards. The latest criteria published by EPA are those listed in the National Toxics Rule (57 *FR* 60848) and the Stay of Federal Water Quality Criteria for Metals (60 *FR* 22228). These rules include water quality criteria for 13 metals, and it is these criteria on which this sampling method and the referenced analytical methods are based.

In developing these methods, EPA found that one of the greatest difficulties in measuring pollutants at these levels was precluding sample contamination during collection, transport, and analysis. The degree of difficulty, however, is highly dependent on the metal and site-specific conditions. This method, therefore, is designed to provide the level of protection necessary to preclude contamination in nearly all situations. It is also designed to provide the procedures necessary to produce reliable results at the lowest possible water quality criteria published by EPA. In recognition of the variety of situations to which this method may be applied, and in recognition of continuing technological advances, the method is performance-based. Alternative procedures may be used, so long as those procedures are demonstrated to yield reliable results.

Requests for additional copies of this method should be directed to:

U.S. EPA NCEPI
11029 Kenwood Road
Cincinnati, OH 45242
513/489*8190

Note: This document is intended as guidance only. Use of the terms "must," "may," and "should" are included to mean that EPA believes that these procedures must, may, or should be followed in order to produce the desired results when using this guidance. In addition, the guidance is intended to be performance-based, in that the use of less stringent procedures may be used so long as neither samples nor blanks are contaminated when following those modified procedures. Because the only way to measure the performance of the modified procedures is through the collection and analysis of uncontaminated blank samples in accordance with this guidance and the referenced methods, it is highly recommended that any modifications be thoroughly evaluated and demonstrated to be effective before field samples are collected.

Method 1669

Sampling Ambient Water for Determination of Metals at EPA Water Quality Criteria Levels

1.0 Scope and Application

- 1.1 This method is for the collection and filtration of ambient water samples for subsequent determination of total and dissolved metals at the levels listed in Table 1. It is designed to support the implementation of water quality monitoring and permitting programs administered under the Clean Water Act.
- 1.2 This method is applicable to the metals listed below and other metals, metals species, and elements amenable to determination at trace levels.

Analyte	Symbol	Chemical Abstract Services Registry Number (CASRN)
Antimony	(Sb)	7440-36-0
Arsenic	(As)	7440-38-2
Cadmium	(Cd)	7440-43-9
Chromium (III)	Cr ⁺³	16065-83-1
Chromium (VI)	Cr ⁺⁶	18540-29-9
Copper	(Cu)	7440-50-8
Lead	(Pb)	7439-92-1
Mercury	(Hg)	7439-97-6
Nickel	(Ni)	7440-02-0
Selenium	(Se)	7782-49-2
Silver	(Ag)	7440-22-4
Thallium	(Tl)	7440-28-0
Zinc	(Zn)	7440-66-6

- 1.3 This method is accompanied by the 1600 series methods listed in Table 1. These methods include the sample handling, analysis, and quality control procedures necessary for reliable determination of trace metals in aqueous samples.
- 1.4 This method is not intended for determination of metals at concentrations normally found in treated and untreated discharges from industrial facilities. Existing regulations (40CFR Parts 400-500) typically limit concentrations in industrial discharges to the mid to high part-per-billion (ppb) range, whereas ambient metals concentrations are normally in the low part-per-trillion (ppt) to low ppb range. This guidance is therefore directed at the collection of samples to be measured at or near the levels listed in Table 1. Actual concentration ranges to which this guidance is applicable will be dependent on the sample matrix, dilution levels, and other laboratory operating conditions.
- 1.5 The ease of contaminating ambient water samples with the metal(s) of interest and interfering substances cannot be overemphasized. This method includes sampling techniques that should maximize the ability of the sampling team to collect samples reliably and eliminate sample contamination. These techniques are given in Section 8.0 and are based on findings of researchers performing trace metals analyses (References 1-9).

- 1.6 Clean and Ultraclean The terms "clean" and "ultraclean" have been used in other Agency guidance to describe the techniques needed to reduce or eliminate contamination in trace metals determinations. These terms are not used in this sampling method due to a lack of exact definitions. However, the information provided in this method is consistent with summary guidance on clean and ultraclean techniques (Reference 10).
- 1.7 This sampling method follows the EPA Environmental Methods Management Council's "Format for Method Documentation" (Reference 11).
- 1.8 Method 1669 is "performance-based"; i.e., an alternate sampling procedure or technique may be used, so long as neither samples nor blanks are contaminated when following the alternate procedures. Because the only way to measure the performance of the alternate procedures is through the collection and analysis of uncontaminated blank samples in accordance with this guidance and the methods referenced in Table 1, it is highly recommended that any modifications be thoroughly evaluated and demonstrated to be effective before field samples are collected. Section 9.2 provides additional details on the tests and documentation required to support equivalent performance.
- 1.9 For dissolved metal determinations, samples must be filtered through a 0.45 μm capsule filter at the field site. The filtering procedures are described in this method. The filtered samples may be preserved in the field or transported to the laboratory for preservation. Procedures for field preservation are detailed in this sampling method; procedures for laboratory preservation are provided in the methods referenced in Table 1. Preservation requirements are summarized in Table 2.
- 1.10 The procedures in this method are for use only by personnel thoroughly trained in the collection of samples for determination of metals at ambient water quality control levels.

2.0 Summary of Method

- 2.1 Before samples are collected, all sampling equipment and sample containers are cleaned in a laboratory or cleaning facility using detergent, mineral acids, and reagent water as described in the methods referenced in Table 1. The laboratory or cleaning facility is responsible for generating an acceptable equipment blank to demonstrate that the sampling equipment and containers are free from trace metals contamination before they are shipped to the field sampling team. An acceptable blank is one that is free from contamination below the minimum level (ML) specified in the referenced analytical method (Section 9.3).
- 2.2 After cleaning, sample containers are filled with weak acid solution, individually double-bagged, and shipped to the sampling site. All sampling equipment is also bagged for storage or shipment.

NOTE: EPA has found that, in some cases, it may be possible to empty the weak acid solution from the bottle immediately prior to transport to the field site. In this case, the bottle should be refilled with reagent water (Section 7.1).

- 2.3 The laboratory or cleaning facility must prepare a large carboy or other appropriate clean container filled with reagent water (Section 7.1) for use with collection of field blanks during sampling activities. The reagent-water-filled container should be shipped to the field site and handled as all other sample containers and sampling equipment. At least one field blank should be processed per site, or one per every ten samples, whichever is more frequent (Section 9.4). If samples are to be

collected for determination of trivalent chromium, the sampling team processes additional QC aliquots are processed as described in Section 9.6.

- 2.4 Upon arrival at the sampling site, one member of the two-person sampling team is designated as "dirty hands"; the second member is designated as "clean hands." All operations involving contact with the sample bottle and transfer of the sample from the sample collection device to the sample bottle are handled by the individual designated as "clean hands." "Dirty hands" is responsible for preparation of the sampler (except the sample container itself), operation of any machinery, and for all other activities that do not involve direct contact with the sample.
- 2.5 All sampling equipment and sample containers used for metals determinations at or near the levels listed in Table 1 must be nonmetallic and free from any material that may contain metals.
- 2.6 Sampling personnel are required to wear clean, nontalc gloves at all times when handling sampling equipment and sample containers.
- 2.7 In addition to processing field blanks at each site, a field duplicate must be collected at each sampling site, or one field duplicate per every 10 samples, whichever is more frequent (Section 9.5). Section 9.0 gives a complete description of quality control requirements.
- 2.8 Sampling
 - 2.8.1 Whenever possible, samples are collected facing upstream and upwind to minimize introduction of contamination.
 - 2.8.2 Samples may be collected while working from a boat or while on land.
 - 2.8.3 Surface samples are collected using a grab sampling technique. The principle of the grab technique is to fill a sample bottle by rapid immersion in water and capping to minimize exposure to airborne particulate matter.
 - 2.8.4 Subsurface samples are collected by suction of the sample into an immersed sample bottle or by pumping the sample to the surface.
- 2.9 Samples for dissolved metals are filtered through a 0.45 μm capsule filter at the field site. After filtering, the samples are double-bagged and iced immediately. Sample containers are shipped to the analytical laboratory. The sampling equipment is shipped to the laboratory or cleaning facility for recleaning.
- 2.10 Acid preservation of samples is performed in the field or in the laboratory. Field preservation is necessary for determinations of trivalent chromium. It has also been shown that field preservation can increase sample holding times for hexavalent chromium to 30 days; therefore it is recommended that preservation of samples for hexavalent chromium be performed in the field. For other metals, however, the sampling team may prefer to utilize laboratory preservation of samples to expedite field operations and to minimize the potential for sample contamination.
- 2.11 Sampling activities must be documented through paper or computerized sample tracking systems.

3.0 Definitions

- 3.1 Apparatus"Throughout this method, the sample containers, sampling devices, instrumentation, and all other materials and devices used in sample collection, sample processing, and sample analysis activities will be referred to collectively as the Apparatus.

3.2 Definitions of other terms are given in the Glossary (Section 15.0) at the end of this method.

4.0 Contamination and Interferences

4.1 Contamination Problems in Trace Metals Analysis

4.1.1 Preventing ambient water samples from becoming contaminated during the sampling and analytical process is the greatest challenge faced in trace metals determinations. In recent years, it has been shown that much of the historical trace metals data collected in ambient water are erroneously high because the concentrations reflect contamination from sampling and analysis rather than ambient levels (Reference 12). Therefore, it is imperative that extreme care be taken to avoid contamination when collecting and analyzing ambient water samples for trace metals.

4.1.2 There are numerous routes by which samples may become contaminated. Potential sources of trace metals contamination during sampling include metallic or metal-containing sampling equipment, containers, labware (e.g. talc gloves that contain high levels of zinc), reagents, and deionized water; improperly cleaned and stored equipment, labware, and reagents; and atmospheric inputs such as dirt and dust from automobile exhaust, cigarette smoke, nearby roads, bridges, wires, and poles. Even human contact can be a source of trace metals contamination. For example, it has been demonstrated that dental work (e.g., mercury amalgam fillings) in the mouths of laboratory personnel can contaminate samples that are directly exposed to exhalation (Reference 3).

4.2 Contamination Control

4.2.1 Philosophy The philosophy behind contamination control is to ensure that any object or substance that contacts the sample is nonmetallic and free from any material that may contain metals of concern.

4.2.1.1 The integrity of the results produced cannot be compromised by contamination of samples. Requirements and suggestions for controlling sample contamination are given in this sampling method and in the analytical methods referenced in Table 1.

4.2.1.2 Substances in a sample or in the surrounding environment cannot be allowed to contaminate the Apparatus used to collect samples for trace metals measurements. Requirements and suggestions for protecting the Apparatus are given in this sampling method and in the methods referenced in Table 1.

4.2.1.3 While contamination control is essential, personnel health and safety remain the highest priority. Requirements and suggestions for personnel safety are given in Section 5 of this sampling method and in the methods referenced in Table 1.

4.2.2 Avoiding contamination The best way to control contamination is to completely avoid exposure of the sample and Apparatus to contamination in the first place. Avoiding exposure means performing operations in an area known to be free from contamination. Two of the most important factors in avoiding/reducing sample contamination are (1) an awareness of potential sources of contamination and (2) strict attention to work being performed. Therefore, it is imperative that the procedures described in this method be

carried out by well trained, experienced personnel. Documentation of training should be kept on file and readily available for review.

- 4.2.2.1 Minimize exposure^aThe Apparatus that will contact samples or blanks should only be opened or exposed in a clean room, clean bench, glove box, or clean plastic bag, so that exposure to atmospheric inputs is minimized. When not being used, the Apparatus should be covered with clean plastic wrap, stored in the clean bench or in a plastic box or glove box, or bagged in clean, colorless zip-type bags. Minimizing the time between cleaning and use will also reduce contamination.
- 4.2.2.2 Wear gloves^aSampling personnel must wear clean, nontalc gloves (Section 6.7) during all operations involving handling of the Apparatus, samples, and blanks. Only clean gloves may touch the Apparatus. If another object or substance is touched, the glove(s) must be changed before again handling the Apparatus. If it is even suspected that gloves have become contaminated, work must be halted, the contaminated gloves removed, and a new pair of clean gloves put on. Wearing multiple layers of clean gloves will allow the old pair to be quickly stripped with minimal disruption to the work activity.
- 4.2.2.3 Use metal-free Apparatus^aAll Apparatus used for metals determinations at the levels listed in Table 1 must be nonmetallic and free of material that may contain metals. When it is not possible to obtain equipment that is completely free of the metal(s) of interest, the sample should not come into direct contact with the equipment.
- 4.2.2.3.1 Construction materials^aOnly the following materials should come in contact with samples: fluoropolymer (FEP, PTFE), conventional or linear polyethylene, polycarbonate, polysulfone, polypropylene, or ultrapure quartz. PTFE is less desirable than FEP because the sintered material in PTFE may contain contaminants and is susceptible to serious memory effects (Reference 6). Fluoropolymer or glass containers should be used for samples that will be analyzed for mercury because mercury vapors can diffuse in or out of other materials, resulting either in contamination or low-biased results (Reference 3). Metal must not be used under any circumstance. Regardless of construction, all materials that will directly or indirectly contact the sample must be cleaned using the procedures described in the referenced analytical methods (see Table 1) and must be known to be clean and metal-free before proceeding.
- 4.2.2.3.2 The following materials have been found to contain trace metals and must not be used to hold liquids that come in contact with the sample or must not contact the sample, unless these materials have been shown to be free of the metals of interest at the desired level: Pyrex, Kimax, methacrylate, polyvinylchloride, nylon, and Vycor (Reference 6). In addition, highly colored plastics, paper cap liners, pigments used to mark increments on plastics, and rubber all contain trace levels of metals and must be avoided (Reference 13).

- 4.2.2.3.3 **Serialization**"Serial numbers should be indelibly marked or etched on each piece of Apparatus so that contamination can be traced, and logbooks should be maintained to track the sample from the container through the sampling process to shipment to the laboratory. Chain-of-custody procedures may also be used if warranted so that contamination can be traced to particular handling procedures or lab personnel.
- 4.2.2.3.4 The Apparatus should be clean when the sampling team receives it. If there are any indications that the Apparatus is not clean (e.g., a ripped storage bag), an assessment of the likelihood of contamination must be made. Sampling must not proceed if it is possible that the Apparatus is contaminated. If the Apparatus is contaminated, it must be returned to the laboratory or cleaning facility for proper cleaning before any sampling activity resumes.
- 4.2.2.3.5 Details for recleaning the Apparatus between collection of individual samples are provided in Section 10.0.
- 4.2.2.4 **Avoid sources of contamination**"Avoid contamination by being aware of potential sources and routes of contamination.
 - 4.2.2.4.1 **Contamination by carryover**"Contamination may occur when a sample containing low concentrations of metals is processed immediately after a sample containing relatively high concentrations of these metals. At sites where more than one sample will be collected, the sample known or expected to contain the lowest concentration of metals should be collected first with the sample containing the highest levels collected last (Section 8.1.4). This will help minimize carryover of metals from high- concentration samples to low- concentration samples. If the sampling team does not have prior knowledge of the waterbody, or when necessary, the sample collection system should be rinsed with dilute acid and reagent water between samples and followed by collection of a field blank (Section 10.3).
 - 4.2.2.4.2 **Contamination by samples**"Significant contamination of the Apparatus may result when untreated effluents, in-process waters, landfill leachates, and other samples containing mid to high-level concentrations of inorganic substances are processed. As stated in Section 1.0, this sampling method is not intended for application to these samples, and samples containing high concentrations of metals must not be collected, processed, or shipped at the same time as samples being collected for trace metals determinations.
 - 4.2.2.4.3 **Contamination by indirect contact**"Apparatus that may not directly contact samples may still be a source of contamination. For example, clean tubing placed in a dirty plastic bag may pick up contamination from the bag and subsequently transfer the contamination to the sample. Therefore, it is imperative that every piece of the Apparatus that is directly or indirectly used in

the collection of ambient water samples be cleaned as specified in the analytical method(s) referenced in Table 1.

4.2.2.4.4

Contamination by airborne particulate matter^aLess obvious substances capable of contaminating samples include airborne particles. Samples may be contaminated by airborne dust, dirt, particulate matter, or vapors from automobile exhaust; cigarette smoke; nearby corroded or rusted bridges, pipes, poles, or wires; nearby roads; and even human breath (Section 4.1.2). Whenever possible, the sampling activity should occur as far as possible from sources of airborne contamination (Section 8.1.3). Areas where nearby soil is bare and subject to wind erosion should be avoided.

- 4.3 Interferences^aInterferences resulting from samples will vary considerably from source to source, depending on the diversity of the site being sampled. If a sample is suspected of containing substances that may interfere in the determination of trace metals, sufficient sample should be collected to allow the laboratory to identify and overcome interference problems.

5.0 Safety

- 5.1 The toxicity or carcinogenicity of the chemicals used in this method has not been precisely determined; however, these chemicals should be treated as a potential health hazard. Exposure should be reduced to the lowest possible level. Sampling teams are responsible for maintaining a current awareness file of OSHA regulations for the safe handling of the chemicals specified in this method. A reference file of Material Safety Data Sheets should also be made available to all personnel involved in sampling. It is also suggested that the organization responsible perform personal hygiene monitoring of each sampling team member who uses this method and that the results of this monitoring be made available to the member.
- 5.2 Operating in and around waterbodies carries the inherent risk of drowning. Life jackets must be worn when operating from a boat, when sampling in more than a few feet of water, or when sampling in swift currents.
- 5.3 Collecting samples in cold weather, especially around cold water bodies, carries the risk of hypothermia, and collecting samples in extremely hot and humid weather carries the risk of dehydration and heat stroke. Sampling team members should wear adequate clothing for protection in cold weather and should carry an adequate supply of water or other liquids for protection against dehydration in hot weather.

6.0 Apparatus and Materials

NOTE: Brand names, suppliers, and part numbers are for illustration only and no endorsement is implied. Equivalent performance may be achieved using apparatus and materials other than those specified here. Meeting the performance requirements of this method is the responsibility of the sampling team and laboratory.

- 6.1 All sampling equipment and sample containers must be precleaned in a laboratory or cleaning facility, as described in the methods referenced in Table 1, before they are shipped to the field site. Performance criteria for equipment cleaning is described in the referenced methods. To minimize

difficulties in sampling, the equipment should be packaged and arranged to minimize field preparation.

- 6.2 Materials such as gloves (Section 6.7), storage bags (Section 6.8), and plastic wrap (Section 6.9), may be used new without additional cleaning unless the results of the equipment blank pinpoint any of these materials as a source of contamination. In this case, either a different supplier must be obtained or the materials must be cleaned.
- 6.3 Sample Bottles"Fluoropolymer (FEP, PTFE), conventional or linear polyethylene, polycarbonate, or polypropylene; 500 mL or 1 L with lids. If mercury is a target analyte, fluoropolymer or glass bottles should be used. Refer to the methods referenced in Table 1 for bottle cleaning procedures.
 - 6.3.1 Cleaned sample bottles should be filled with 0.1% HCl (v/v). In some cases, it may be possible to empty the weak acid solution from the sample bottle immediately prior to transport to the field site. In this case, the bottle should be refilled with reagent water (Section 7.1).
 - 6.3.2 Whenever possible, sampling devices should be cleaned and prepared for field use in a class 100 clean room. Preparation of the devices in the field should be done within the glove bag (Section 6.6). Regardless of design, sampling devices must be constructed of nonmetallic material (Section 4.2.2.3.1) and free from material that contains metals. Fluoropolymer or other material shown not to adsorb or contribute mercury must be used if mercury is a target analyte; otherwise, polyethylene, polycarbonate, or polypropylene are acceptable. Commercially available sampling devices may be used provided that any metallic or metal-containing parts are replaced with parts constructed of nonmetallic material.
- 6.4 Surface Sampling Devices"Surface samples are collected using a grab sampling technique. Samples may be collected manually by direct submersion of the bottle into the water or by using a grab sampling device. Examples of grab samplers are shown in Figures 1 and 2 and may be used at sites where depth profiling is neither practical nor necessary.
 - 6.4.1 The grab sampler in Figure 1 consists of a heavy fluoropolymer collar fastened to the end of a 2-m-long polyethylene pole, which serves to remove the sampling personnel from the immediate vicinity of the sampling point. The collar holds the sample bottle. A fluoropolymer closing mechanism, threaded onto the bottle, enables the sampler to open and close the bottle under water, thereby avoiding surface microlayer contamination (Reference 14). Polyethylene, polycarbonate, and polypropylene are also acceptable construction materials unless mercury is a target analyte. Assembly of the cleaned sampling device is as follows (refer to Figure 1):
 - 6.4.1.1 Thread the pull cord (with the closing mechanism attached) through the guides and secure the pull ring with a simple knot. Screw a sample bottle onto the closing device and insert the bottle into the collar. Cock the closing plate so that the plate is pushed away from the operator.
 - 6.4.1.2 The cleaned and assembled sampling device should be stored in a double layer of large, clean zip-type polyethylene bags or wrapped in two layers of clean polyethylene wrap if it will not be used immediately.
 - 6.4.2 An alternate grab sampler design is shown in Figure 2. This grab sampler is used for discrete water samples and is constructed so that a capped clean bottle can be submerged,

the cap removed, sample collected, and bottle recapped at a selected depth. This device eliminates sample contact with conventional samplers (e.g., Niskin bottles), thereby reducing the risk of extraneous contamination. Because a fresh bottle is used for each sample, carryover from previous samples is eliminated (Reference 15).

- 6.5 Subsurface Sampling Devices*Subsurface sample collection may be appropriate in lakes and sluggish deep river environments or where depth profiling is determined to be necessary. Subsurface samples are collected by pumping the sample into a sample bottle. Examples of subsurface collection systems include the jar system device shown in Figure 3 and described in Section 6.5.1 or the continuous-flow apparatus shown in Figure 4 and described in Section 6.5.2.

- 6.5.1 Jar sampler (Reference 14)*The jar sampler (Figure 3) is comprised of a heavy fluoropolymer 1-L jar with a fluoropolymer lid equipped with two 1/4 in. fluoropolymer fittings. Sample enters the jar through a short length of fluoropolymer tubing inserted into one fitting. Sample is pulled into the jar by pumping on fluoropolymer tubing attached to the other fitting. A thick fluoropolymer plate supports the jar and provides attachment points for a fluoropolymer safety line and fluoropolymer torpedo counterweight.

- 6.5.1.1 Advantages of the jar sampler for depth sampling are (1) all wetted surfaces are fluoropolymer and can be rigorously cleaned; (2) the sample is collected into a sample jar from which the sample is readily recovered, and the jar can be easily recleaned; (3) the suction device (a peristaltic or rotary vacuum pump, Section 6.15) is located in the boat, isolated from the sampling jar; (4) the sampling jar can be continuously flushed with sample, at sampling depth, to equilibrate the system; and (5) the sample does not travel through long lengths of tubing that are more difficult to clean and keep clean (Reference 14). In addition, the device is designed to eliminate atmospheric contact with the sample during collection.

- 6.5.1.2 To assemble the cleaned jar sampler, screw the torpedo weight onto the machined bolt attached to the support plate of the jar sampler. Attach a section of the 1/4 in. o.d. tubing to the jar by inserting the tubing into the fitting on the lid and pushing down into the jar until approximately 8 cm from the bottom. Tighten the fitting nut securely. Attach the solid safety line to the jar sampler using a bowline knot to the loop affixed to the support plate.

- 6.5.1.3 For the tubing connecting the pump to the sampler, tubing lengths of up to 12 m have been used successfully (Reference 14).

- 6.5.2 Continuous-flow sampler (References 16-17)*This sampling system, shown in Figure 4, consists of a peristaltic or submersible pump and one or more lengths of precleaned fluoropolymer or styrene/ethylene/butylene/silicone (SEBS) tubing. A filter is added to the sampling train when sampling for dissolved metals.

- 6.5.2.1 Advantages of this sampling system include (1) all wetted surfaces are fluoropolymer or SEBS and can be readily cleaned; (2) the suction device is located in the boat, isolated from the sample bottle; (3) the sample does not travel through long lengths of tubing that are difficult to clean and keep clean; and (4) in-line filtration is possible, minimizing field handling requirements for dissolved metals samples.

- 6.5.2.2 The sampling team assembles the system in the field as described in Section 8.2.8. System components include an optional polyethylene pole to remove sampling

personnel from the immediate vicinity of the sampling point and the pump, tubing, filter, and filter holder listed in Sections 6.14 and 6.15.

- 6.6 Field-Portable Glove Bag[®]I2R, Model R-37-37H (nontalc), or equivalent. Alternately, a portable glove box may be constructed with a nonmetallic (PVC pipe or other suitable material) frame and a frame cover made of an inexpensive, disposable, nonmetallic material (e.g., a thin-walled polyethylene bag) (Reference 7).
- 6.7 Gloves[®]Clean, nontalc polyethylene, latex, vinyl, or PVC; various lengths. Shoulder-length gloves are needed if samples are to be collected by direct submersion of the sample bottle into the water or when sampling for mercury.
 - 6.7.1 Gloves, shoulder-length polyethylene[®]Associated Bag Co., Milwaukee, WI, 66-3-301, or equivalent.
 - 6.7.2 Gloves, PVC[®]Fisher Scientific Part No. 11-394-100B, or equivalent.
- 6.8 Storage Bags[®]Clean, zip-type, nonvented, colorless polyethylene (various sizes).
- 6.9 Plastic Wrap[®]Clean, colorless polyethylene.
- 6.10 Cooler[®]Clean, nonmetallic, with white interior for shipping samples.
- 6.11 Ice or Chemical Refrigerant Packs[®]To keep samples chilled in the cooler during shipment.
- 6.12 Wind Suit[®]Pamida, or equivalent.

NOTE: This equipment is necessary only for collection of metals, such as mercury, that are known to have elevated atmospheric concentrations.

- 6.12.1 An unlined, long-sleeved wind suit consisting of pants and jacket and constructed of nylon or other synthetic fiber is worn when sampling for mercury to prevent mercury adsorbed onto cotton or other clothing materials from contaminating samples.
- 6.12.2 Washing and drying[®]The wind suit is washed by itself or with other wind suits only in a home or commercial washing machine and dried in a clothes dryer. The clothes dryer must be thoroughly vacuumed, including the lint filter, to remove all traces of lint before drying. After drying, the wind suit is folded and stored in a clean polyethylene bag for shipment to the sample site.
- 6.13 Boat
 - 6.13.1 For most situations (e.g., most metals under most conditions), the use of an existing, available boat is acceptable. A flat-bottom, Boston Whaler-type boat is preferred because sampling materials can be stored with reduced chance of tipping.
 - 6.13.1.1 Immediately before use, the boat should be washed with water from the sampling site away from any sampling points to remove any dust or dirt accumulation.
 - 6.13.1.2 Samples should be collected upstream of boat movement.

6.13.2 For mercury, and for situations in which the presence of contaminants cannot otherwise be controlled below detectable levels, the following equipment and precautions may be necessary:

- 6.13.2.1 A metal-free (e.g., fiberglass) boat, along with wooden or fiberglass oars. Gasoline- or diesel-fueled boat motors should be avoided when possible because the exhaust can be a source of contamination. If the body of water is large enough to require use of a boat motor, the engine should be shut off at a distance far enough from the sampling point to avoid contamination, and the sampling team should manually propel the boat to the sampling point. Samples should be collected upstream of boat movement.
- 6.13.2.2 Before first use, the boat should be cleaned and stored in an area that minimizes exposure to dust and atmospheric particles. For example, cleaned boats should not be stored in an area that would allow exposure to automobile exhaust or industrial pollution.
- 6.13.2.3 The boat should be frequently visually inspected for possible contamination.
- 6.13.2.4 After sampling, the boat should be returned to the laboratory or cleaning facility, cleaned as necessary, and stored away from any sources of contamination until next use.

6.14 Filtration Apparatus^aRequired when collecting samples for dissolved metals determinations.

- 6.14.1 Filter^a0.45 μm , 15 mm diameter or larger, tortuous-path capsule filters (Reference 18), Gelman Supor 12175, or equivalent.
- 6.14.2 Filter holder^aFor mounting filter to the gunwale of the boat. Rod or pipe made from plastic material and mounted with plastic clamps.

NOTE: A filter holder may not be required if one or a few samples are to be collected. For these cases, it may only be necessary to attach the filter to the outlet of the tubing connected to the pump.

6.15 Pump and Pump Apparatus^aRequired for use with the jar sampling system (Section 6.5.1) or the continuous-flow system (Section 6.5.2). Peristaltic pump; 115 V a.c., 12 V d.c., internal battery, variable-speed, single-head, Cole-Parmer, portable, "Masterflex L/S," Catalog No. H-07570-10 drive with Quick Load pump head, Catalog No. H07021-24, or equivalent.

NOTE: Equivalent pumps may include rotary vacuum, submersible, or other pumps free from metals and suitable to meet the site-specific depth sampling needs.

- 6.15.1 Cleaning^aPeristaltic pump modules do not require cleaning. However, nearly all peristaltic pumps contain a metal head and metal controls. Touching the head or controls necessitates changing of gloves before touching the Apparatus. If a submersible pump is used, a large volume of sample should be pumped to clean the stainless steel shaft (hidden behind the impeller) that comes in contact with the sample. Pumps with metal impellers should not be used.

- 6.15.2 Tubing*For use with peristaltic pump. SEBS resin, approximately 3/8 in. i.d. by approximately 3 ft, Cole-Parmer size 18, Cat. No. G-06464-18, or approximately 1/4 in. i.d., Cole-Parmer size 17, Catalog No. G-06464-17, or equivalent. Tubing is cleaned by soaking in 5-10% HCl solution for 8-24 hours, rinsing with reagent water in a clean bench in a clean room, and drying in the clean bench by purging with mercury-free air or nitrogen. After drying, the tubing is double-bagged in clear polyethylene bags, serialized with a unique number, and stored until use.
- 6.15.3 Tubing*For connection to peristaltic pump tubing. Fluoropolymer, 3/8 or 1/4 in. o.d., in lengths as required to reach the point of sampling. If sampling will be at some depth from the end of a boom extended from a boat, sufficient tubing to extend to the end of the boom and to the depth will be required. Cleaning of the fluoropolymer can be the same as cleaning the tubing for the rotary vacuum pump (Section 6.15.1.2). If necessary, more aggressive cleaning (e.g., concentrated nitric acid) may be used.
- 6.15.4 Batteries to operate submersible pump*12 V, 2.6 amp, gel cell, YUASA NP2.6-12, or equivalent. A 2 amp fuse connected at the positive battery terminal is strongly recommended to prevent short circuits from overheating the battery. A 12 V, lead-acid automobile or marine battery may be more suitable for extensive pumping.
- 6.15.5 Tubing connectors*Appropriately sized PVC, clear polyethylene, or fluoropolymer "barbed" straight connectors cleaned as the tubing above. Used to connect multiple lengths of tubing.
- 6.16 Carboy*For collection and storage of dilute waste acids used to store bottles.
- 6.17 Apparatus*For field preservation of aliquots for trivalent chromium determinations.
- 6.17.1 Fluoropolymer forceps*1 L fluoropolymer jar, and 30 mL fluoropolymer vials with screw-caps (one vial per sample and blank). It is recommended that 1 mL of ultrapure nitric acid (Section 7.3) be added to each vial prior to transport to the field to simplify field handling activities (See Section 8.4.4.6).
- 6.17.2 Filters*0.4 μm , 47 mm polycarbonate Nuclepore (or equivalent). Filters are cleaned as follows. Fill a 1 L fluoropolymer jar approximately two-thirds full with 1 N nitric acid. Using fluoropolymer forceps, place individual filters in the fluoropolymer jar. Allow the filters to soak for 48 hours. Discard the acid, and rinse five times with reagent water. Fill the jar with reagent water, and soak the filters for 24 hours. Remove the filters when ready for use, and using fluoropolymer forceps, place them on the filter apparatus (Section 6.17.3).
- 6.17.3 Vacuum filtration apparatus*Millipore 47 mm size, or equivalent, vacuum pump and power source (and extension cords, if necessary) to operate the pump.
- 6.17.4 Eppendorf auto pipet and colorless pipet tips (100/1000 μL)
- 6.17.5 Wrist-action shaker*Burrel or equivalent.
- 6.17.6 Fluoropolymer wash bottles*One filled with reagent water (Section 7.1) and one filled with high-purity 10% HCl (Section 7.4.4), for use in rinsing forceps and pipet tips.

7.0 Reagents and Standards

- 7.1 Reagent Water*Water in which the analytes of interest and potentially interfering substances are not detected at the Method Detection Limit (MDL) of the analytical method used for analysis of samples. Prepared by distillation, deionization, reverse osmosis, anodic/cathodic stripping voltammetry, or other techniques that remove the metal(s) and potential interferent(s). A large carboy or other appropriate container filled with reagent water must be available for the collection of field blanks.
- 7.2 Nitric Acid*Dilute, trace-metal grade, shipped with sampling kit for cleaning equipment between samples.
- 7.3 Sodium Hydroxide*Concentrated, 50% solution for use when field-preserving samples for hexavalent chromium determinations (Section 8.4.5).
- 7.4 Reagents*For field-processing aliquots for trivalent chromium determinations
- 7.4.1 Nitric Acid, Ultrapure*For use when field-preserving samples for trivalent chromium determinations (Sections 6.17 and 8.4.4).
- 7.4.2 Ammonium Iron (II) Sulfate Solution (0.01M)*Used to prepare the chromium (III) extraction solution (Section 7.4.3) necessary for field preservation of samples for trivalent chromium (Section 8.4.4). Prepare the ammonium iron (II) sulfate solution by adding 3.92 g ammonium iron (II) sulfate (ultrapure grade) to a 1 L volumetric flask. Bring to volume with reagent water. Store in a clean polyethylene bottle.
- 7.4.3 Chromium (III) extraction solution*For use when field-preserving samples for trivalent chromium determinations (Section 8.4.4). Prepare this solution by adding 100 mL of ammonium iron (II) sulfate solution (Section 7.4.2) to a 125 mL polyethylene bottle. Adjust pH to 8 with approximately 2 mL of ammonium hydroxide solution. Cap and shake on a wrist-action shaker for 24 hours. This iron (III) hydroxide solution is stable for 30 days.
- 7.4.4 Hydrochloric acid*High-purity, 10% solution, shipped with sampling kit in fluoropolymer wash bottles for cleaning trivalent chromium sample preservation equipment between samples.
- 7.4.5 Chromium stock standard solution (1000 µg/mL)*Prepared by adding 3.1 g anhydrous chromium chloride to a 1 L flask and diluting to volume with 1% hydrochloric acid. Store in polyethylene bottle. A commercially available standard solution may be substituted.
- 7.4.6 Standard chromium spike solution (1000 µg/L)*Used to spike sample aliquots for matrix spike/matrix spike duplicate (MS/MSD) analysis and to prepare ongoing precision and recovery standards. Prepared by spiking 1 mL of the chromium stock standard solution (Section 7.4.5) into a 1 L flask. Dilute to volume with 1% HCl. Store in a polyethylene bottle.
- 7.4.7 Ongoing precision and recovery (OPR) standard (25 µg/L)*Prepared by spiking 2.5 mL of the standard chromium spike solution (Section 7.4.6) into a 100 mL flask. Dilute to volume with 1% HCl. One OPR is required for every 10 samples.

8.0 Sample Collection, Filtration, and Handling

8.1 Site Selection

- 8.1.1 Selection of a representative site for surface water sampling is based on many factors including: study objectives, water use, point source discharges, non-point source discharges, tributaries, changes in stream characteristics, types of stream bed, stream depth, turbulence, and the presence of structures (bridges, dams, etc.). When collecting samples to determine ambient levels of trace metals, the presence of potential sources of metal contamination are of extreme importance in site selection.
- 8.1.2 Ideally, the selected sampling site will exhibit a high degree of cross-sectional homogeneity. It may be possible to use previously collected data to identify locations for samples that are well mixed or are vertically or horizontally stratified. Since mixing is principally governed by turbulence and water velocity, the selection of a site immediately downstream of a riffle area will ensure good vertical mixing. Horizontal mixing occurs in constrictions in the channel. In the absence of turbulent areas, the selection of a site that is clear of immediate point sources, such as industrial effluents, is preferred for the collection of ambient water samples (Reference 19).
- 8.1.3 To minimize contamination from trace metals in the atmosphere, ambient water samples should be collected from sites that are as far as possible (e.g., at least several hundred feet) from any metal supports, bridges, wires or poles. Similarly, samples should be collected as far as possible from regularly or heavily traveled roads. If it is not possible to avoid collection near roadways, it is advisable to study traffic patterns and plan sampling events during lowest traffic flow (Reference 7).
- 8.1.4 The sampling activity should be planned to collect samples known or suspected to contain the lowest concentrations of trace metals first, finishing with the samples known or suspected to contain the highest concentrations. For example, if samples are collected from a flowing river or stream near an industrial or municipal discharge, the upstream sample should be collected first, the downstream sample collected second, and the sample nearest the discharge collected last. If the concentrations of pollutants is not known and cannot be estimated, it is necessary to use precleaned sampling equipment at each sampling location.

- 8.2 Sample Collection Procedure"Before collecting ambient water samples, consideration should be given to the type of sample to be collected, the amount of sample needed, and the devices to be used (grab, surface, or subsurface samplers). Sufficient sample volume should be collected to allow for necessary quality control analyses, such as matrix spike/matrix spike duplicate analyses.

8.2.1 Four sampling procedures are described:

- 8.2.1.1 Section 8.2.5 describes a procedure for collecting samples directly into the sample container. This procedure is the simplest and provides the least potential for contamination because it requires the least amount of equipment and handling.
- 8.2.1.2 Section 8.2.6 describes a procedure for using a grab sampling device to collect samples.

8.2.1.3 Section 8.2.7 describes a procedure for depth sampling with a jar sampler. The size of sample container used is dependent on the amount of sample needed by the analytical laboratory.

8.2.1.4 Section 8.2.8 describes a procedure for continuous-flow sampling using a submersible or peristaltic pump.

8.2.2 The sampling team should ideally approach the site from down current and downwind to prevent contamination of the sample by particles sloughing off the boat or equipment. If it is not possible to approach from both, the site should be approached from down current if sampling from a boat or approached from downwind if sampling on foot. When sampling from a boat, the bow of the boat should be oriented into the current (the boat will be pointed upstream). All sampling activity should occur from the bow.

If the samples are being collected from a boat, it is recommended that the sampling team create a stable workstation by arranging the cooler or shipping container as a work table on the upwind side of the boat, covering this worktable and the upwind gunnel with plastic wrap or a plastic tablecloth, and draping the wrap or cloth over the gunnel. If necessary, duct tape is used to hold the wrap or cloth in place.

8.2.3 All operations involving contact with the sample bottle and with transfer of the sample from the sample collection device to the sample bottle (if the sample is not directly collected in the bottle) are handled by the individual designated as "clean hands." "Dirty hands" is responsible for all activities that do not involve direct contact with the sample.

Although the duties of "clean hands" and "dirty hands" would appear to be a logical separation of responsibilities, in fact, the completion of the entire protocol may require a good deal of coordination and practice. For example, "dirty hands" must open the box or cooler containing the sample bottle and unzip the outer bag; clean hands must reach into the outer bag, open the inner bag, remove the bottle, collect the sample, replace the bottle lid, put the bottle back into the inner bag, and zip the inner bag. "Dirty hands" must close the outer bag and place it in a cooler.

To minimize unnecessary confusion, it is recommended that a third team member be available to complete the necessary sample documentation (e.g., to document sampling location, time, sample number, etc). Otherwise, "dirty hands" must perform the sample documentation activity (Reference 7).

8.2.4 Extreme care must be taken during all sampling operations to minimize exposure of the sample to human, atmospheric, and other sources of contamination. Care must be taken to avoid breathing directly on the sample, and whenever possible, the sample bottle should be opened, filled, and closed while submerged.

8.2.5 Manual collection of surface samples directly into the sample bottle.

8.2.5.1 At the site, all sampling personnel must put on clean gloves (Section 6.7) before commencing sample collection activity, with "clean hands" donning shoulder-length gloves. If samples are to be analyzed for mercury, the sampling team must also put their precleaned wind suits on at this time. Note that "clean hands" should put on the shoulder-length polyethylene gloves (Section 6.7.1) and both "clean hands" and "dirty hands" should put on the PVC gloves (Section 6.7.2).

- 8.2.5.2 "Dirty hands" must open the cooler or storage container, remove the double-bagged sample bottle from storage, and unzip the outer bag.
- 8.2.5.3 Next, "clean hands" opens the inside bag containing the sample bottle, removes the bottle, and reseals the inside bag. "Dirty hands" then reseals the outer bag.
- 8.2.5.4 "Clean hands" unscrews the cap and, while holding the cap upside down, discards the dilute acid solution from the bottle into a carboy for wastes (Section 6.16) or discards the reagent water directly into the water body.
- 8.2.5.5 "Clean hands" then submerges the sample bottle, and allows the bottle to partially fill with sample. "Clean hands" screws the cap on the bottle, shakes the bottle several times, and empties the rinsate away from the site. After two more rinsings, "clean hands" holds the bottle under water and allows bottle to fill with sample. After the bottle has filled (i.e., when no more bubbles appear), and while the bottle is still inverted so that the mouth of the bottle is underwater, "clean hands" replaces the cap of the bottle. In this way, the sample has never contacted the air.
- 8.2.5.6 Once the bottle lid has been replaced, "dirty hands" reopens the outer plastic bag, and "clean hands" opens the inside bag, places the bottle inside it, and zips the inner bag.
- 8.2.5.7 "Dirty hands" zips the outer bag.
- 8.2.5.8 Documentation" After each sample is collected, the sample number is documented in the sampling log, and any unusual observations concerning the sample and the sampling are documented.
- 8.2.5.9 If the sample is to be analyzed for dissolved metals, it is filtered in accordance with the procedure described in Section 8.3.
- 8.2.6 Sample collection with grab sampling device" The following steps detail sample collection using the grab sampling device shown in Figure 1 and described in Section 6.4.1. The procedure is indicative of the "clean hands/dirty hands" technique that must be used with alternative grab sampling devices such as that shown in Figure 2 and described in Section 6.4.2.
 - 8.2.6.1 The sampling team puts on gloves (and wind suits, if applicable). Ideally, a sample bottle will have been preattached to the sampling device in the class 100 clean room at the laboratory. If it is necessary to attach a bottle to the device in the field, "clean hands" performs this operation, described in Section 6.4.2, inside the field-portable glove bag (Section 6.6).
 - 8.2.6.2 "Dirty hands" removes the sampling device from its storage container and opens the outer polyethylene bag.
 - 8.2.6.3 "Clean hands" opens the inside polyethylene bag and removes the sampling device.
 - 8.2.6.4 "Clean hands" changes gloves.

- 8.2.6.5 "Dirty hands" submerges the sampling device to the desired depth and pulls the fluoropolymer pull cord to bring the seal plate into the middle position so that water can enter the bottle.
- 8.2.6.6 When the bottle is full (i.e., when no more bubbles appear), "dirty hands" pulls the fluoropolymer cord to the final stop position to seal off the sample and removes the sampling device from the water.
- 8.2.6.7 "Dirty hands" returns the sampling device to its large inner plastic bag, "clean hands" pulls the bottle out of the collar, unscrews the bottle from the sealing device, and caps the bottle. "Clean hands" and "dirty hands" then return the bottle to its double-bagged storage as described in Sections 8.2.5.6 through 8.2.5.7.
- 8.2.6.8 Closing mechanism "Clean hands" removes the closing mechanism from the body of the grab sampler, rinses the device with reagent water (Section 7.1), places it inside a new clean plastic bag, zips the bag, and places the bag inside an outer bag held by "dirty hands." "Dirty hands" zips the outer bag and places the double-bagged closing mechanism in the equipment storage box.
- 8.2.6.9 Sampling device "Clean hands" seals the large inside bag containing the collar, pole, and cord and places the bag into a large outer bag held by "dirty hands." "Dirty hands" seals the outside bag and places the double-bagged sampling device into the equipment storage box.
- 8.2.6.10 Documentation After each sample is collected, the sample number is documented in the sampling log, and any unusual observations concerning the sample and the sampling are documented.
- 8.2.6.11 If the sample is to be analyzed for dissolved metals, it is filtered in accordance with the procedures described in Section 8.3.
- 8.2.7 Depth sampling using a jar sampling device (Figure 3 and Section 6.5.1)
- 8.2.7.1 The sampling team puts on gloves (and wind suits, if applicable) and handles bottles as with manual collection (Sections 8.2.5.1 through 8.2.5.4 and 8.2.5.6 through 8.2.5.7).
- 8.2.7.2 "Dirty hands" removes the jar sampling device from its storage container and opens the outer polyethylene bag.
- 8.2.7.3 "Clean hands" opens the inside polyethylene bag and removes the jar sampling apparatus. Ideally, the sampling device will have been preassembled in a class 100 clean room at the laboratory. If, however, it is necessary to assemble the device in the field, "clean hands" must perform this operation, described in Section 6.5.2, inside a field-portable glove bag (Section 6.6).
- 8.2.7.4 While "dirty hands" is holding the jar sampling apparatus, "clean hands" connects the pump to the 1/4 in. o.d. flush line.
- 8.2.7.5 "Dirty hands" lowers the weighted sampler to the desired depth.

- 8.2.7.6 "Dirty hands" turns on the pump allowing a large volume (>2 L) of water to pass through the system.
- 8.2.7.7 After stopping the pump, "dirty hands" pulls up the line, tubing, and device and places them into either a field-portable glove bag or a large, clean plastic bag as they emerge.
- 8.2.7.8 Both "clean hands" and "dirty hands" change gloves.
- 8.2.7.9 Using the technique described in Sections 8.2.5.2 through 8.2.5.4, the sampling team removes a sample bottle from storage, and "clean hands" places the bottle into the glove bag.
- 8.2.7.10 "Clean hands" tips the sampling jar and dispenses the sample through the short length of fluoropolymer tubing into the sample bottle.
- 8.2.7.11 Once the bottle is filled, "clean hands" replaces the cap of the bottle, returns the bottle to the inside polyethylene bag, and zips the bag. "Clean hands" returns the zipped bag to the outside polyethylene bag held by "dirty hands."
- 8.2.7.12 "Dirty hands" zips the outside bag. If the sample is to be analyzed for dissolved metals, it is filtered as described in Section 8.3.
- 8.2.7.13 Documentation" After each sample is collected, the sample number is documented in the sampling log, and any unusual observations concerning the sample and the sampling are documented.
- 8.2.8 Continuous-flow sampling (Figure 4 and Section 6.5.2)"The continuous-flow sampling system uses peristaltic pump (Section 6.15) to pump sample to the boat or to shore through the SEBS-resin or PTFE tubing.
 - 8.2.8.1 Before putting on wind suits or gloves, the sampling team removes the bags containing the pump (Section 6.15), SEBS-resin tubing (Section 6.15.2), batteries (Section 6.15.4), gloves (Section 6.7), plastic wrap (Section 6.9), wind suits (Section 6.12), and, if samples are to be filtered, the filtration apparatus (Section 6.14) from the coolers or storage containers in which they are packed.
 - 8.2.8.2 "Clean hands" and "dirty hands" put on the wind suits and PVC gloves (Section 6.7.2).
 - 8.2.8.3 "Dirty hands" removes the pump from its storage bag, and opens the bag containing the SEBS-resin tubing.
 - 8.2.8.4 "Clean hands" installs the tubing while "dirty hands" holds the pump. "Clean hands" immerses the inlet end of the tubing in the sample stream.
 - 8.2.8.5 Both "clean hands" and "dirty hands" change gloves. "Clean hands" also puts on shoulder length polyethylene gloves (Section 6.7.1).
 - 8.2.8.6 "Dirty hands" turns the pump on and allows the pump to run for 5-10 minutes or longer to purge the pump and tubing.

- 8.2.8.7 If the sample is to be filtered, "clean hands" installs the filter at the end of the tubing, and "dirty hands" sets up the filter holder on the gunwale as shown in Figure 4.

NOTE: The filtration apparatus is not attached until immediately before sampling to prevent buildup of particulates from clogging the filter.

- 8.2.8.8 The sample is collected by rinsing the sample bottle and cap three times and collecting the sample from the flowing stream.

- 8.2.8.9 Documentation*After each sample is collected, the sample number is documented in the sampling log, and any unusual observations concerning the sample and the sampling are documented.

- 8.3 Sample Filtration*The filtration procedure described below is used for samples collected using the manual (Section 8.2.5), grab (Section 8.2.6), or jar (Section 8.2.7) collection systems (Reference 7). In-line filtration using the continuous-flow approach is described in Section 8.2.8.7. Because of the risk of contamination, it is recommended that samples for mercury be shipped unfiltered by overnight courier and filtered when received at the laboratory.
- 8.3.1 Set up the filtration system inside the glove bag, using the shortest piece of pump tubing as is practicable. Place the peristaltic pump immediately outside of the glove bag and poke a small hole in the glove bag for passage of the tubing. Also, attach a short length of tubing to the outlet of the capsule filter.
- 8.3.2 "Clean hands" removes the water sample from the inner storage bag using the technique described in Sections 8.2.5.2 through 8.2.5.4 and places the sample inside the glove bag. "Clean hands" also places two clean empty sample bottles, a bottle containing reagent water, and a bottle for waste in the glove bag.
- 8.3.3 "Clean hands" removes the lid of the reagent water bottle and places the end of the pump tubing in the bottle.
- 8.3.4 "Dirty hands" starts the pump and passes approximately 200 mL of reagent water through the tubing and filter into the waste bottle. "Clean hands" then moves the outlet tubing to a clean bottle and collects the remaining reagent water as a blank. "Dirty hands" stops the pump.
- 8.3.5 "Clean hands" removes the lid of the sample bottle and places the intake end of the tubing in the bottle.
- 8.3.6 "Dirty hands" starts the pump and passes approximately 50 mL through the tubing and filter into the remaining clean sample bottle and then stops the pump. "Clean hands" uses the filtrate to rinse the bottle, discards the waste sample, and returns the outlet tube to the sample bottle.
- 8.3.7 "Dirty hands" starts the pump and the remaining sample is processed through the filter and collected in the sample bottle. If preservation is required, the sample is acidified at this point (Section 8.4).

- 8.3.8 "Clean hands" replaces the lid on the bottle, returns the bottle to the inside bag, and zips the bag. "Clean hands" then places the zipped bag into the outer bag held by "dirty hands."
- 8.3.9 "Dirty hands" zips the outer bag, and places the double-bagged sample bottle into a clean, ice-filled cooler for immediate shipment to the laboratory.

NOTE: *It is not advisable to reclean and reuse filters. The difficulty and risk associated with failing to properly clean these devices far outweighs the cost of purchasing a new filter.*

8.4 Preservation

- 8.4.1 Field preservation is not necessary for dissolved metals, except for trivalent and hexavalent chromium, provided that the sample is preserved in the laboratory and allowed to stand for at least two days to allow the metals adsorbed to the container walls to redissolve. Field preservation is advised for hexavalent chromium in order to provide sample stability for up to 30 days. Mercury samples should be shipped by overnight courier and preserved when received at the laboratory.
- 8.4.2 If field preservation is required, preservation must be performed in the glove bag or in a designated clean area, with gloved hands, as rapidly as possible to preclude particulates from contaminating the sample. For preservation of trivalent chromium, the glove bag or designated clean area must be large enough to accommodate the vacuum filtration apparatus (Section 6.17.3), and an area should be available for setting up the wrist-action shaker (Section 6.17.5). It is also advisable to set up a work area that contains a "clean" cooler for storage of clean equipment, a "dirty" cooler for storage of "dirty" equipment, and a third cooler to store samples for shipment to the laboratory.
- 8.4.3 Preservation of aliquots for metals other than trivalent and hexavalent chromium*Using a disposable, precleaned, plastic pipet, add 5 mL of a 10% solution of ultrapure nitric acid in reagent water per liter of sample. This will be sufficient to preserve a neutral sample to pH <2.
- 8.4.4 Preservation of aliquots for trivalent chromium (References 89).
 - 8.4.4.1 Decant 100 mL of the sample into a clean polyethylene bottle.
 - 8.4.4.2 Clean an Eppendorf pipet by pipeting 1 mL of 10% HCl (Section 7.4.4) followed by 1 mL of reagent water into an acid waste container. Use the rinsed pipet to add 1 mL of chromium (III) extraction solution (Section 7.4.3) to each sample and blank.
 - 8.4.4.3 Cap each bottle tightly, place in a clean polyethylene bag, and shake on a wrist action shaker (Section 6.17.5) for one hour.
 - 8.4.4.4 Vacuum-filter the precipitate through a 0.4 µm pretreated filter membrane (Section 6.17.2), using fluoropolymer forceps (Section 6.17.1) to handle the membrane, and a 47 mm vacuum filtration apparatus with a precleaned filter holder (Section 6.17.3). After all sample has filtered, rinse the inside of the filter holder with approximately 15 mL of reagent water.
 - 8.4.4.5 Using the fluoropolymer forceps, fold the membrane in half and then in quarters,

taking care to avoid touching the side containing the filtrate to any surface. (Folding is done while the membrane is sitting on the filter holder and allows easy placement of the membrane into the sample vial). Transfer the filter to a 30 mL fluoropolymer vial. If the fluoropolymer vial was not pre-equipped with the ultrapure nitric acid (Section 7.4.1), rinse the pipet by drawing and discharging 1 mL of 10% HCl followed by 1 mL of reagent water into a waste container, and add 1 mL of ultrapure nitric acid to the sample vial.

8.4.4.6 Cap the vial and double-bag it for shipment to the laboratory.

8.4.4.7 Repeat Steps 8.4.4.4-8.4.4.6 for each sample, rinsing the fluoropolymer forceps and the pipet with 10% high-purity HCl followed by reagent water between samples.

8.4.5 Preservation of aliquots for hexavalent chromium (Reference 20).

8.4.5.1 Decant 125 mL of sample into a clean polyethylene bottle.

8.4.5.2 Prepare an Eppendorf pipet by pipeting 1 mL of 10% HCl (Section 7.4.4) followed by 1 mL of reagent water into an acid waste container. Use the rinsed pipet to add 1 mL NaOH to each 125 mL sample and blank aliquot.

8.4.5.3 Cap the vial(s) and double-bag for shipment to the laboratory.

9.0 Quality Assurance/Quality Control

9.1 The sampling team shall employ a strict quality assurance/ quality control (QA/QC) program. The minimum requirements of this program include the collection of equipment blanks, field blanks, and field replicates. It is also desirable to include blind QC samples as part of the program. If samples will be processed for trivalent chromium determinations, the sampling team shall also prepare method blank, OPR, and MS/MSD samples as described in Section 9.6.

9.2 The sampling team is permitted to modify the sampling techniques described in this method to improve performance or reduce sampling costs, provided that reliable analyses of samples are obtained and that samples and blanks are not contaminated. Each time a modification is made to the procedures, the sampling team is required to demonstrate that the modification does not result in contamination of field and equipment blanks. The requirements for modification are given in Sections 9.3 and 9.4. Because the acceptability of a modification is based on the results obtained with the modification, the sampling team must work with an analytical laboratory capable of making trace metals determinations to demonstrate equivalence.

9.3 Equipment Blanks

9.3.1 Before using any sampling equipment at a given site, the laboratory or equipment cleaning contractor is required to generate equipment blanks to demonstrate that the equipment is free from contamination. Two types of equipment blanks are required: bottle blanks and sampling equipment blanks.

9.3.2 Equipment blanks must be run on all equipment that will be used in the field. If, for example, samples are to be collected using both a grab sampling device and the jar sampling device, then an equipment blank must be run on both pieces of equipment.

- 9.3.3 Equipment blanks are generated in the laboratory or at the equipment cleaning contractor's facility by processing reagent water through the equipment using the same procedures that are used in the field (Section 8.0). Therefore, the "clean hands/dirty hands" technique used during field sampling should be followed when preparing equipment blanks at the laboratory or cleaning facility. In addition, training programs must require must require sampling personnel to collect a clean equipment blank before performing on-site field activities.
 - 9.3.4 Detailed procedures for collecting equipment blanks are given in the analytical methods referenced in Table 1.
 - 9.3.5 The equipment blank must be analyzed using the procedures detailed in the referenced analytical method (see Table 1). If any metal(s) of interest or any potentially interfering substance is detected in the equipment blank at the minimum level specified in the referenced method, the source of contamination/interference must be identified and removed. The equipment must be demonstrated to be free from the metal(s) of interest before the equipment may be used in the field.
- 9.4 Field Blank
 - 9.4.1 To demonstrate that sample contamination has not occurred during field sampling and sample processing, at least one field blank must be generated for every 10 samples that are collected at a given site. Field blanks are collected before sample collection.
 - 9.4.2 Field blanks are generated by filling a large carboy or other appropriate container with reagent water (Section 7.1) in the laboratory, transporting the filled container to the sampling site, processing the water through each of the sample processing steps and equipment (e.g., tubing, sampling devices, filters, etc.) that will be used in the field, collecting the field blank in one of the sample bottles, and shipping the bottle to the laboratory for analysis in accordance with the method(s) referenced in Table 1. For example, manual grab sampler field blanks are collected by directly submerging a sample bottle into the water, filling the bottle, and capping. Subsurface sampler field blanks are collected by immersing the tubing into the water and pumping water into a sample container.
 - 9.4.3 Filter the field blanks using the procedures described in Section 8.3.
 - 9.4.4 If it is necessary to acid clean the sampling equipment between samples (Section 10.0), a field blank should be collected after the cleaning procedures but before the next sample is collected.
 - 9.4.5 If trivalent chromium aliquots are processed, a separate field blank must be collected and processed through the sample preparation steps given in Sections 8.4.4.1 through 8.4.4.6.
- 9.5 Field Duplicate
 - 9.5.1 To assess the precision of the field sampling and analytical processes, at least one field duplicate sample must be collected for every 10 samples that are collected at a given site.
 - 9.5.2 The field duplicate is collected either by splitting a larger volume into two aliquots in the glove box, by using a sampler with dual inlets that allows simultaneous collection of two samples, or by collecting two samples in rapid succession.

- 9.5.3 Field duplicates for dissolved metals determinations must be processed using the procedures in Section 8.3. Field duplicates for trivalent chromium must be processed through the sample preparation steps given in Sections 8.4.4.1 through 8.4.4.6.
- 9.6 Additional QC for Collection of Trivalent Chromium Aliquots
- 9.6.1 Method blank "The sampling team must prepare one method blank for every ten or fewer field samples. Each method blank is prepared using the steps in Sections 8.4.4.1 through 8.4.4.6 on a 100 mL aliquot of reagent water (Section 7.1). Do not use the procedures in Section 8.3 to process the method blank through the 0.45 μ m filter (Section 6.14.1), even if samples are being collected for dissolved metals determinations.
- 9.6.2 Ongoing precision and recovery (OPR) "The sampling team must prepare one OPR for every ten or fewer field samples. The OPR is prepared using the steps in Sections 8.4.4.1 through 8.4.4.6 on the OPR standard (Section 7.4.7). Do not use the procedures in Section 8.3 to process the OPR through the 0.45 μ m filter (Section 6.14.1), even if samples are being collected for dissolved metals determinations.
- 9.6.3 MS/MSD "The sampling team must prepare one MS and one MSD for every ten or fewer field samples.
- 9.6.3.1 If, through historical data, the background concentration of the sample can be estimated, the MS and MSD samples should be spiked at a level of one to five times the background concentration.
- 9.6.3.2 For samples in which the background concentration is unknown, the MS and MSD samples should be spiked at a concentration of 25 μ g/L.
- 9.6.3.3 Prepare the matrix spike sample by spiking a 100-mL aliquot of sample with 2.5 mL of the standard chromium spike solution (Section 7.4.6), and processing the MS through the steps in Sections 8.4.4.1 through 8.4.4.6.
- 9.6.3.4 Prepare the matrix spike duplicate sample by spiking a second 100-mL aliquot of the same sample with 2.5 mL of the standard chromium spike solution, and processing the MSD through the steps in Sections 8.4.4.1 through 8.4.4.6.
- 9.6.3.5 If field samples are collected for dissolved metals determinations, it is necessary to process an MS and an MSD through the 0.45 μ m filter as described in Section 8.3.

10.0 Recleaning the Apparatus Between Samples

- 10.1 Sampling activity should be planned so that samples known or suspected to contain the lowest concentrations of trace metals are collected first with the samples known or suspected to contain the highest concentrations of trace metals collected last. In this manner, cleaning of the sampling equipment between samples is unnecessary. If it is not possible to plan sampling activity in this manner, dedicated sampling equipment should be provided for each sampling event.
- 10.2 If samples are collected from adjacent sites (e.g., immediately upstream or downstream), rinsing of the sampling Apparatus with water that is to be sampled should be sufficient.

- 10.3 If it is necessary to cross a gradient (i.e., going from a high-concentration sample to a low-concentration sample), such as might occur when collecting at a second site, the following procedure may be used to clean the sampling equipment between samples:

10.3.1 In the glove bag, and using the "clean hands/dirty hands" procedure in Section 8.2.5, process the dilute nitric acid solution (Section 7.2) through the Apparatus.

10.3.2 Dump the spent dilute acid in the waste carboy or in the waterbody away from the sampling point.

10.3.3 Process 1 L of reagent water through the Apparatus to rinse the equipment and discard the spent water.

10.3.4 Collect a field blank as described in Section 9.4.

10.3.5 Rinse the Apparatus with copious amounts of the ambient water sample and proceed with sample collection.

- 10.4 Procedures for recleaning trivalent chromium preservation equipment between samples are described in Section 8.4.4.

11.0 Method Performance

Samples were collected in the Great Lakes during September*October 1994 using the procedures in this sampling method.

12.0 Pollution Prevention

- 12.1 The only materials used in this method that could be considered pollutants are the acids used in the cleaning of the Apparatus, the boat, and related materials. These acids are used in dilute solutions in small amounts and pose little threat to the environment when managed properly.
- 12.2 Cleaning solutions containing acids should be prepared in volumes consistent with use to minimize the disposal of excessive volumes of acid.
- 12.3 To the extent possible, the Apparatus used to collect samples should be cleaned and reused to minimize the generation of solid waste.

13.0 Waste Management

- 13.1 It is the sampling team's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the discharge regulations, hazardous waste identification rules, and land disposal restrictions; and to protect the air, water, and land by minimizing and controlling all releases from field operations.
- 13.2 For further information on waste management, consult *The Waste Management Manual for Laboratory Personnel* and *Less is Better: Laboratory Chemical Management for Waste Reduction*, available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th Street NW, Washington, DC 20036.

14.0 References

1. Adeboju, S.B. and Bond, A.M. "Influence of Laboratory Environment on the Precision and Accuracy of Trace Element Analysis," *Anal. Chem.* **1985**, *57*, 1728.
2. Berman, S.S. and Yeats, P.A. "Sampling of Seawater for Trace Metals," *CRC Reviews in Analytical Chemistry* **1985**, *16*.
3. Bloom, N.S. "Ultra-Clean Sampling, Storage, and Analytical Strategies for the Accurate Determination of Trace Metals in Natural Waters." Presented at the 16th Annual EPA Conference on the Analysis of Pollutants in the Environment, Norfolk, VA, May 5, 1993.
4. Bruland, K.W. "Trace Elements in Seawater," *Chemical Oceanography* **1983**, *8*, 157.
5. Nriagu, J.O., Larson, G., Wong, H.K.T., and Azcue, J.M. "A Protocol for Minimizing Contamination in the Analysis of Trace Metals in Great Lakes Waters," *J. Great Lakes Research* **1993**, *19*, 175.
6. Patterson, C.C. and Settle, D.M. "Accuracy in Trace Analysis," in *National Bureau of Standards Special Publication 422*; LaFleur, P.D., Ed., U.S. Government Printing Office, Washington, DC, 1976.
7. "A Protocol for the Collection and Processing of Surface-Water Samples for Subsequent Determination of Trace Elements, Nutrients, and Major Ions in Filtered Water"; Office of Water Quality Technical Memorandum 94.09, Office of Water Quality, Water Resources Division, U.S. Geological Survey, Reston, VA, Jan. 28, 1994.
8. Standard Operating Procedure No. 4-54, Revision 01, *SOP for Concentration and Analysis of Chromium Species in Whole Seawater*; Prepared by Battelle Ocean Sciences, Duxbury, MA for the U.S. Environmental Protection Agency Office of Marine Environmental Protection, Ocean Incineration Research Program, 1987.
9. Cranston, R.E. and Murray, J.W. "The Determination of Chromium Species in Natural Waters," *Anal. Chem. Acta* **1978**, *99*, 275.
10. Prothro, M.G. "Office of Water Policy and Technical Guidance on Interpretation and Implementation of Aquatic Life Metals Criteria"; EPA Memorandum to Regional Water Management and Environmental Services Division Directors, Oct. 1, 1993.
11. "Format for Method Documentation"; Distributed by the EPA Environmental Monitoring Management Council, Washington, DC, Nov. 18, 1993.
12. Windom, H.L., Byrd, J.T., Smith, R.G., Jr., and Huan, F. "Inadequacy of NASQAN Data for Assessing Metal Trends in the Nation's Rivers," *Environ. Sci. Technol.* **1991**, *25*, 1137.
13. Zief, M. and Mitchell, J.W. "Contamination Control in Trace Metals Analysis," *Chemical Analysis* **1976**, *47*, Chapter 6.
14. Phillips, H., Shafer, M., Dean, P., Walker, M., and Armstrong, D. "Recommendations for Trace Metals Analysis of Natural Waters"; Wisconsin Department of Natural Resources: Madison, WI, May 1992.

15. Hunt, C.D. In *Manual of Biological and Geochemical Techniques in Coastal Areas*, 2nd ed.; Lambert, C.E. and Oviatt, C.A., Eds.; Marine Ecosystems Research Laboratory; Graduate School of Oceanography; The University of Rhode Island: Narragansett, RI, MERL Series, Report No. 1, Chapter IV.
16. Flegal, R. Summer 1994 San Francisco Bay Cruise, apparatus and procedures witnessed and videotaped by W. Telliard and T. Fieldsend, Sept. 15-16, 1994.
17. Watras, C. Wisconsin DNR procedures for mercury sampling in pristine lakes in Wisconsin, witnessed and videotaped by D. Rushneck and L. Riddick, Sept. 910, 1994.
18. Horowitz, A.J., Kent A.E., and Colberg, M.R. "The Effect of Membrane Filtration Artifacts on Dissolved Trace Element Concentrations," *Wat. Res.* 1992, 26, 53.
19. *Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual: 1986*; U.S. Environmental Protection Agency. Region IV. Environmental Services Division: Athens, GA.
20. Grohse, P. Research Triangle Institute, Institute Drive, Building 6, Research Triangle Park, NC.
21. Methods 1624 and 1625, 40 *CFR* Part 136, Appendix A.

15.0 Glossary of Definitions and Purposes

These definitions and purposes are specific to this sampling method but have been conformed to common usage as much as possible.

- 15.1 **Ambient Water***Waters in the natural environment (e.g., rivers, lakes, streams, and other receiving waters), as opposed to effluent discharges.
- 15.2 **Apparatus***The sample container and other containers, filters, filter holders, labware, tubing, pipets, and other materials and devices used for sample collection or sample preparation, and that will contact samples, blanks, or analytical standards.
- 15.3 **Equipment Blank***An aliquot of reagent water that is subjected in the laboratory to all aspects of sample collection and analysis, including contact with all sampling devices and apparatus. The purpose of the equipment blank is to determine if the sampling devices and apparatus for sample collection have been adequately cleaned before they are shipped to the field site. An acceptable equipment blank must be achieved before the sampling devices and Apparatus are used for sample collection.
- 15.4 **Field Blank***An aliquot of reagent water that is placed in a sample container in the laboratory, shipped to the field, and treated as a sample in all respects, including contact with the sampling devices and exposure to sampling site conditions, filtration, storage, preservation, and all analytical procedures. The purpose of the field blank is to determine whether the field or sample transporting procedures and environments have contaminated the sample.
- 15.5 **Field Duplicates (FD1 and FD2)***Two identical aliquots of a sample collected in separate sample bottles at the same time and place under identical circumstances using a dual inlet sampler or by splitting a larger aliquot and treated exactly the same throughout field and laboratory procedures. Analyses of FD1 and FD2 give a measure of the precision associated with sample collection, preservation, and storage, as well as with laboratory procedures.

- 15.6 **Matrix Spike (MS) and Matrix Spike Duplicate (MSD)**"Aliquots of an environmental sample to which known quantities of the analytes are added in the laboratory. The MS and MSD are analyzed exactly like a sample. Their purpose is to quantify the bias and precision caused by the sample matrix. The background concentrations of the analytes in the sample matrix must be determined in a separate aliquot and the measured values in the MS and MSD corrected for background concentrations.
- 15.7 **May**"This action, activity, or procedural step is optional.
- 15.8 **May Not**"This action, activity, or procedural step is prohibited.
- 15.9 **Minimum Level (ML)**"The lowest level at which the entire analytical system gives a recognizable signal and acceptable calibration point (Reference 21).
- 15.10 **Must**"This action, activity, or procedural step is required.
- 15.11 **Reagent Water**"Water demonstrated to be free from the metal(s) of interest and potentially interfering substances at the MDL for that metal in the referenced method or additional method.
- 15.12 **Should**"This action, activity, or procedural step is suggested but not required.
- 15.13 **Trace-Metal Grade**"Reagents that have been demonstrated to be free from the metal(s) of interest at the method detection limit (MDL) of the analytical method to be used for determination of this metal(s).

The term "trace-metal grade" has been used in place of "reagent grade" or "reagent" because acids and other materials labeled "reagent grade" have been shown to contain concentrations of metals that will interfere in the determination of trace metals at levels listed in Table 1.

**TABLE 1. ANALYTICAL METHODS, METALS, AND CONCENTRATION LEVELS
APPLICABLE TO METHOD 1669**

Method	Technique	Metal	MDL ($\mu\text{g/L}$) ¹	ML ($\mu\text{g/L}$) ²
1631	Oxidation/Purge & Trap/CVAFS	Mercury	0.0002	0.0005
1632	Hydride AA	Arsenic	0.003	0.01
1636	Ion Chromatography	Hexavalent Chromium	0.23	0.5
1637	CC/STGFAA	Cadmium	0.0075	0.02
		Lead	0.036	0.1
1638	ICP/MS	Antimony	0.0097	0.02
		Cadmium	0.013	0.1
		Copper	0.087	0.2
		Lead	0.015	0.05
		Nickel	0.33	1
		Selenium	0.45	1
		Silver	0.029	0.1
		Thallium	0.0079	0.02
		Zinc	0.14	0.5
1639	STGFAA	Antimony	1.9	5
		Cadmium	0.023	0.05
		Trivalent Chromium	0.10	0.2
		Nickel	0.65	2
		Selenium	0.83	2
		Zinc	0.14	0.5
1640	CC/ICP/MS	Cadmium	0.0024	0.01
		Copper	0.024	0.1
		Lead	0.0081	0.02
		Nickel	0.029	0.1

¹ Method Detection Limit as determined by 40CFR Part 136, Appendix B.

² Minimum Level (ML) calculated by multiplying laboratory-determined MDL by 3.18 and rounding result to nearest multiple of 1, 2, 5, 10, 20, 50, etc., in accordance with procedures used by EAD and described in the EPA Draft National Guidance for the Permitting, Monitoring, and Enforcement of Water Quality-Based Effluent Limitations Set Below Analytical Detection/Quantitation Levels March 22, 1994.

TABLE 2. ANALYTES, PRESERVATION REQUIREMENTS, AND CONTAINERS

Metal	Preservation Requirements	Acceptable Containers
Antimony Arsenic Cadmium Copper Lead Nickel Selenium Silver Thallium Zinc	Add 5 mL of 10% HNO_3 to 1-L sample; preserve on-site or immediately upon laboratory receipt.	500 mL or 1 L fluoropolymer, conventional or linear polyethylene, polycarbonate, or polypropylene containers with lid
Chromium (III)	Add 1 mL chromium (III) extraction solution to 100 mL aliquot, vacuum filter through 0.4 μm membrane, add 1 mL 10% HNO_3 ; preserve on-site immediately after collection.	500 mL or 1 L fluoropolymer, conventional or linear polyethylene, polycarbonate, or polypropylene containers with lid
Chromium (IV)	Add 50% NaOH ; preserve immediately after sample collection.	500 mL or 1 L fluoropolymer, conventional or linear polyethylene, polycarbonate, or polypropylene containers with lid
Mercury	Total: Add 0.5% high-purity HCl or 0.5% BrCl to $\text{pH} < 2$; Total & Methyl: Add 0.5% high-purity HCl ; preserve on-site or immediately upon laboratory receipt	Fluoropolymer or borosilicate glass bottles with fluoropolymer or fluoropolymerlined caps

Figure 1 - Grab Sampling Device

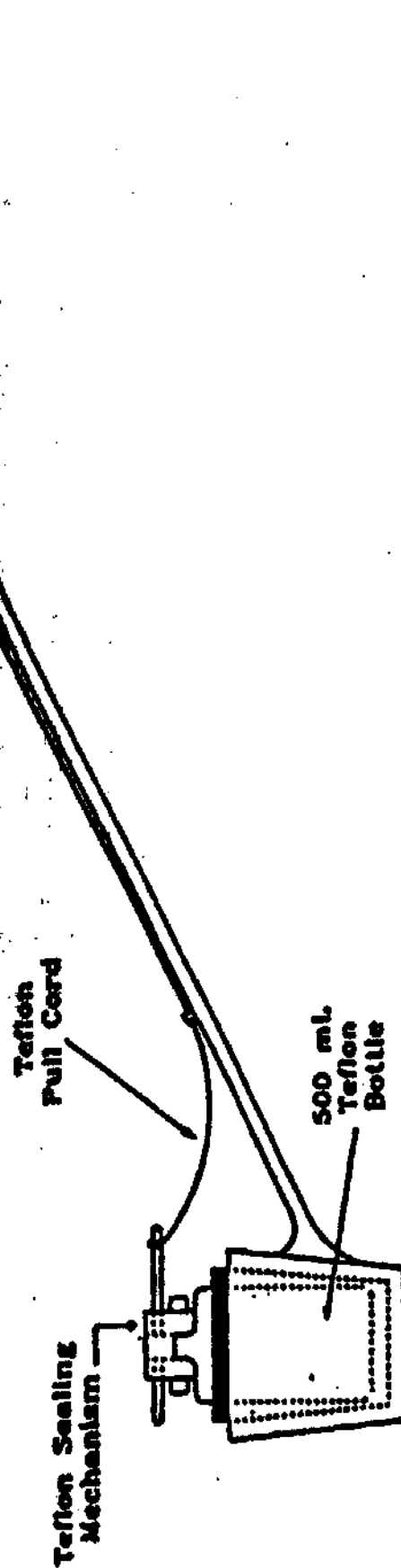


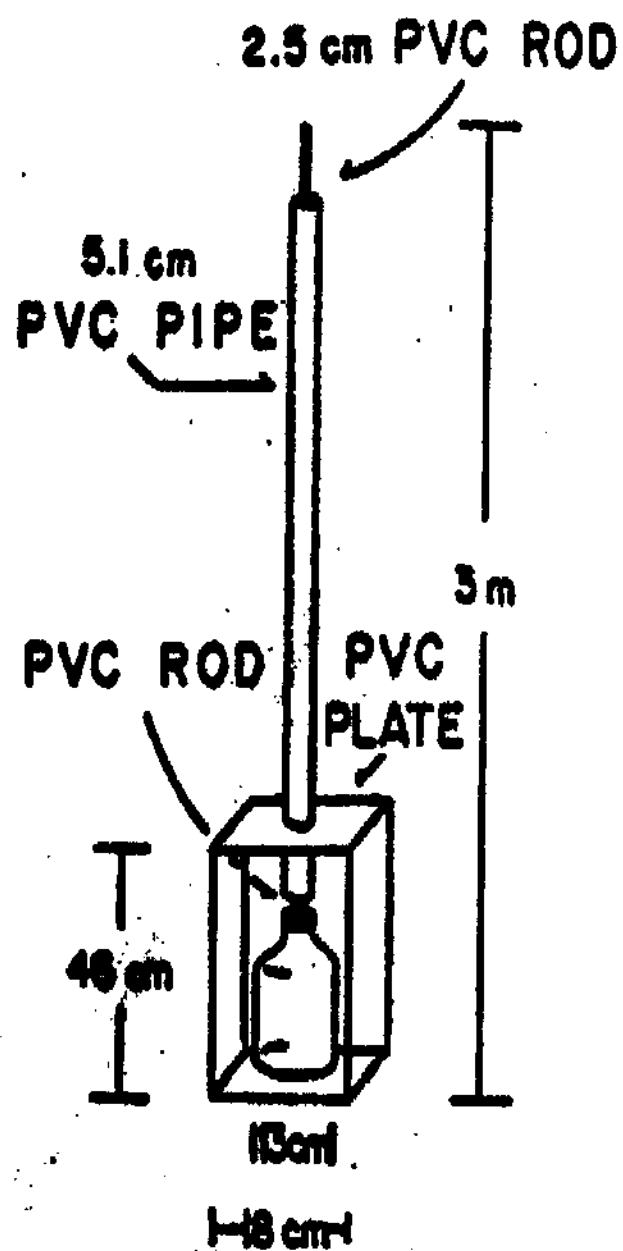
Figure 2 - Grab Sampling Device

Figure 3 - Jar Sampling Device

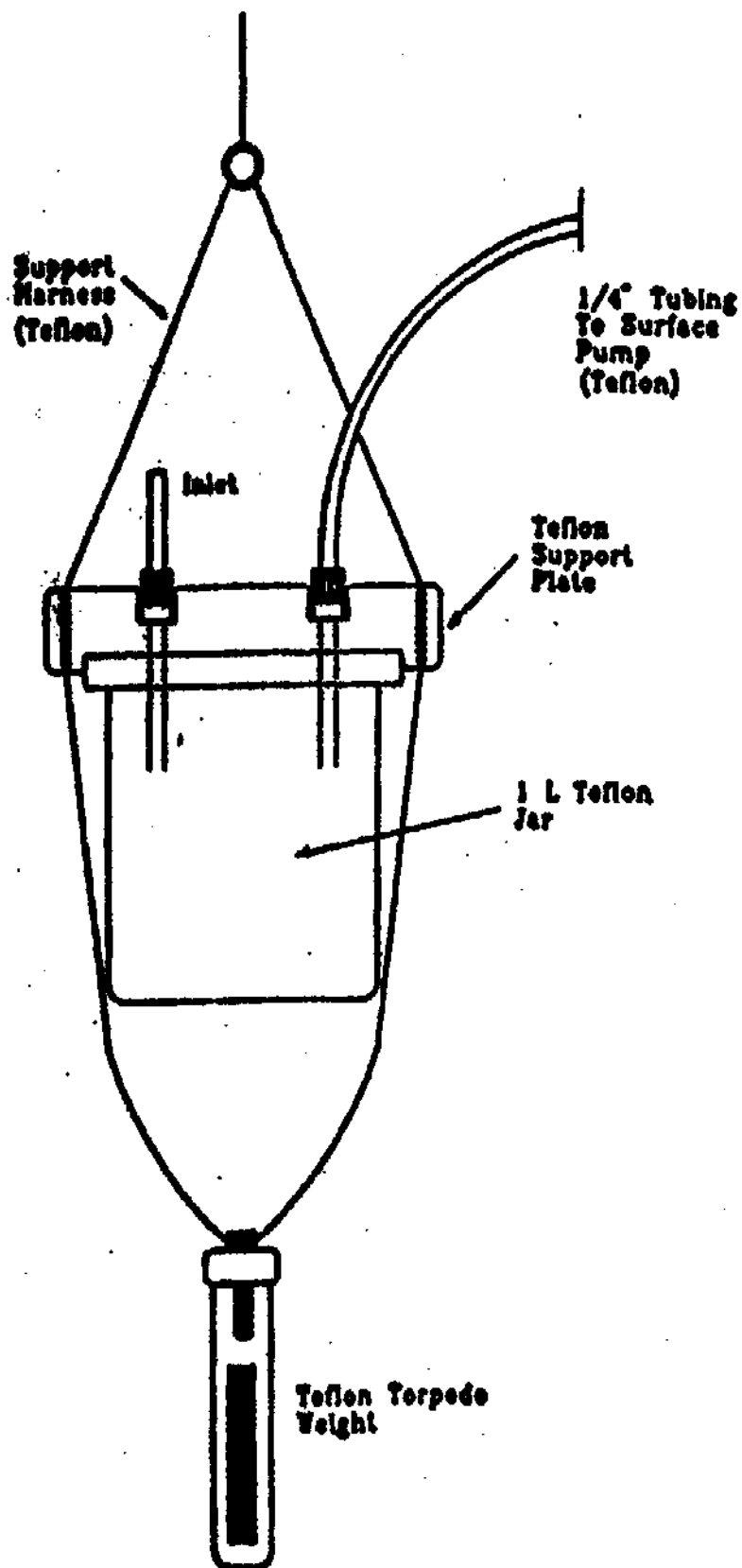


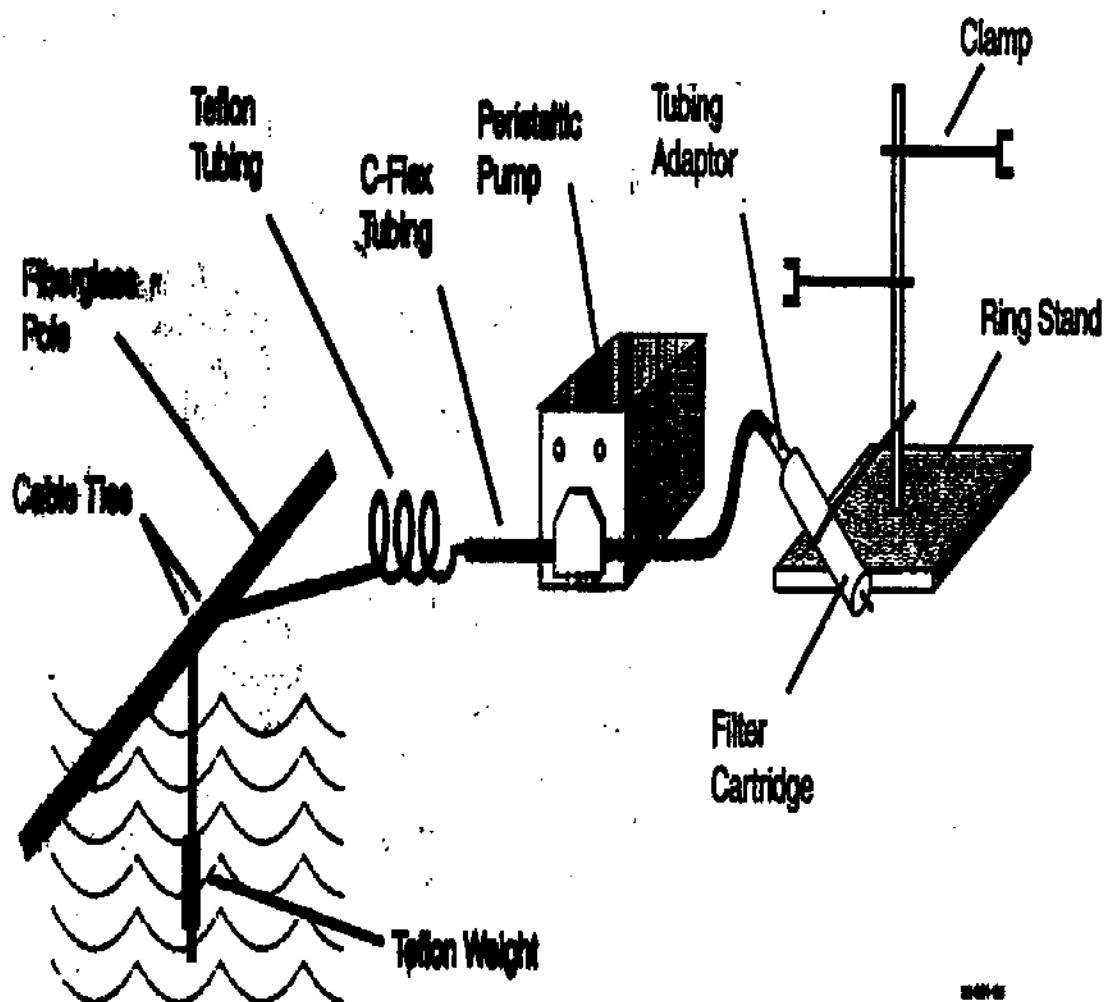
Figure 4 - Sample Pumping System

Figure 4 - Sample Pumping System